N00236_001627
NAS ALAMEDA, CA
SSIC 5000-33c

DRAFT REMEDIAL INVESTIGATION REPORT, OPERABLE UNIT 2, VOLUME 1 OF 7

06/29/1999

TETRA TECH EM, INC.

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COMPREHENSIVE LONG-TERM ENVIRONMENTAL ACTION NAVY (CLEAN II)
Northern and Central California, Nevada, and Utah
Contract No. N62474-94-D-7609
Contract Task Order No. 0167

Prepared for
U.S. DEPARTMENT OF THE NAVY
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OU-2 REMEDIAL INVESTIGATION REPORT
DRAFT
(Chapters 1, 2, 3, 4, and 5, References)

VOLUME I OF VII

ALAMEDA POINT
ALAMEDA, CALIFORNIA

June 29, 1999

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DRAFT OU-2 REMEDIAL INVESTIGATION REPORT
ALAMEDA POINT

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ABBREVIATIONS, ACRONYMS, AND SYMBOLS

°F	-	Degree Fahrenheit
%	-	Percentage contribution toward total risk or hazard from exposure to soil or groundwater
µg/kg	-	Microgram per kilogram
µg/dL	-	Microgram per deciliter
µg/L	-	Microgram per liter
<	-	Less than
>	-	Greater than
1,1,1-TCA	-	1,1,1-Trichloroethane
1,1-DCA	-	1,1-Dichloroethane
1,2-DCA	-	1.2-Dichloroethane
1,2-DCB	-	1,2-Dichlorobenzene
1,2-DCE	-	1,2-Dichloroethene
1,4-DCB	-	1,2-Dichlorobenzene
4,4'-DDD	-	4,4'-Dichlorodiphenyldichloroethane
4,4-DDE	-	4,4-Dichlorodiphenyldichloroethylene
4,4'-DDT	-	4,4'-Dichlorodiphenyltrichloroethane
80 LCL/95	-	80th percent lower confidence limit of the 95th percentile of the distribution
95 UCL	-	95th percent upper confidence limit
ACFCWCD	-	Alameda County Flood Control and Water Conservation District
ACPW	-	Alameda County Public Works
AIMD	-	Aircraft Intermediate Maintenance Department
ARAR	-	Applicable or relevant and appropriate requirement
Army	-	U.S. Army
ARRA	-	Alameda Reuse and Redevelopment Authority
AST	-	Aboveground storage tank
ASTM	-	America Society for Testing and Materials
ATSDR	-	Agency for Toxic Substances and Disease Registry
AVGAS	-	Aviation gasoline
AVG	-	Average exposure
AWQC	-	Ambient water quality criterion
BART	-	Bay Area Regional Transit
Bay Plan	-	The "Water Quality Control Plan of the San Francisco Bay Basin"
BCDC	-	San Francisco Bay Conservation and Development Commission
BCT	-	Base Realignment and Closure Cleanup Team
BCP	-	Base Realignment and Closure Plan
BERC	-	Berkeley Environmental Restoration Center
bgs	-	Below ground surface
BOD	-	Biological oxygen demand
BPTCP	-	Bay Protection and Toxic Cleanup Program
BRAC	-	Base Realignment and Closure
BSU	-	Bay sediment unit
BTAG	-	Biological Technical Advisory Group
BTEX	-	Benzene, toluene, ethylbenzene, and total xylenes
BTF	-	Biotransfer factor

ABBREVIATIONS, ACRONYMS, AND SYMBOLS
(Continued)

Cal/EPA	-	California Environmental Protection Agency
CANS	-	Large shipping containers
CBU	-	Construction Battalion Unit
CCC	-	Criterion continuous concentration
CCR	-	California Code of Regulations
CDC	-	Center for Disease Control and Prevention
CERCLA	-	Comprehensive Environmental Response, Compensation, and Liability Act
CES	-	Canonie Environmental Services
CFR	-	*Code of Federal Regulations*
CHC	-	Chlorinated hydrocarbons
CLEAN	-	Comprehensive Long-Term Environmental Action Navy
CLP	-	Contract Laboratory Program
cm/s	-	Centimeter per second
COC	-	Chemical of concern
COD	-	Chemical oxygen demand
COE	-	U.S. Army Corps of Engineers
COPC	-	Chemical of potential concern
CP	-	Cone penetrometer
CPT	-	Cone penetrometer testing
CRDL	-	Contract-required detection limit
CRQL	-	Contract-required quantitation limit
CSF	-	Carcinogenic slope factor
CSM	-	Conceptual site model
CTO	-	Contract task order
CW	-	Construction worker
DCA	-	Dichloroethane
DCB	-	Dichlorobenzene
DNAPL	-	Dense nonaqueous-phase liquid
DOD	-	U.S. Department of Defense
DPDO	-	Defense Property Disposal Office
DQA	-	Data quality assurance
DQO	-	Data quality objective
DSR	-	Data summary report
DTSC	-	California Department of Toxic Substances Control
DVECC	-	Navy Disease Vector Ecology Control Center
E&E	-	Ecology and Environment Inc.
EBMUD	-	East Bay Municipal Utilities District
EBS	-	Environmental baseline survey
EDC	-	Economic development and conveyance
EFW	-	Einarson, Fowler, and Watson
EIS	-	Environmental impact statement
EOD	-	Explosive ordnance disposal

ABBREVIATIONS, ACRONYMS, AND SYMBOLS
(Continued)

EPA	-	U.S. Environmental Protection Agency
EPC	-	Exposure point concentration
ERA	-	Ecological risk assessment
ERG	-	Environmental Research Group
ERM	-	Environmental Resources Management
ESA	-	Environmental Science Associates
f_{oc}	-	Fractional organic carbon content
FOSL	-	Finding of suitability to lease
FOST	-	Finding of suitability to transfer
FS	-	Feasibility Study
FSP	-	Field sampling plan
ft/ft	-	Foot per foot
ft/min	-	Foot per minute
FTA	-	Fire Training Area
FWBZ	-	First water-bearing zone
FWBZL	-	First water-bearing zone, lower
FWBZU	-	First water bearing zone, upper
GAP	-	Generation accumulation point
GC/MS	-	Gas chromatography/mass spectrometry
GGAS	-	Golden Gate Audubon Society
HCH	-	Gamma-hexachlorocyclohexane
HEAST	-	Health Effects Assessment Summary Tables
HI	-	Hazard index
HLA	-	Harding Lawson Associates
HQ	-	Hazard quotient
HpCDD	-	Heptachlorinated dibenzo-p-dioxin
HpCDF	-	Heptachlorinated dibenzo-furan
HxCDD	-	Hexachlorinated dibenzo-p-dioxin
HxCDF	-	Hexachlorinated dibenzofuran
HHRA	-	Human health risk assessment
HRG	-	Habitat Restoration Group
HSI	-	Hydro-Search Incorporated
IAS	-	Initial assessment study
ILCR	-	Incremental lifetime cancer risk
IMF	-	Intermediate maintenance facility
IR	-	Installation restoration
IRIS	-	Integrated Risk Information System
IRP	-	Installation Restoration Program
IT	-	International Technology Corporation

ABBREVIATIONS, ACRONYMS, AND SYMBOLS
(Continued)

JETC	-	Jet engine test cell
JMM	-	James M. Montgomery
K_d	-	Distribution coefficient
kg	-	Kilogram
kg/L	-	Kilograms per liter
K_{oc}	-	Organic carbon distribution coefficient
lb/in.^{2}	-	Pound per square inch
LCL	-	Lower confidence limit
LCS	-	Laboratory control sample
LCS/LCSD	-	Laboratory control sample/laboratory control sample duplicate
L/day	-	Liters per day
LIF	-	Laser induced fluorescence
L/kg	-	Liters per kilogram
LOEC	-	Lowest observed effect concentration
LOEL	-	Lowest observed effect level
LQAP	-	Laboratory quality assurance plan
m	-	Meter
MCL	-	Maximum contaminant level
MDL	-	Method detection limit
mg/day	-	Milligram per day
mg/kg	-	Milligram per kilogram
mg/kg-day	-	Milligram per kilogram per day
mg/L	-	Milligram per liter
MLLW	-	Mean lower low water
MW	-	Montgomery Watson Consulting Engineers
NA	-	Not available
NACIP	-	Navy Assessment and Control of Installation Pollutants
NADEP	-	Naval Aviation Depot Alameda
NAPL	-	Non-aqueous-phase liquid
NARF	-	Naval Air Rework Facility
NARU	-	Naval Air Reserve Unit
NAS	-	Naval Air Station
NAVREGDENCEN	-	Naval Regional Dental Center
NAVREGMEDCEN	-	Naval Regional Medical Center
Navy	-	U.S. Navy
NCP	-	National Oil and Hazardous Substances Pollution Contingency Plan
NEESA	-	Naval Energy and Environmental Support Activity
NEPA	-	National Environmental Policy Act
NGS	-	National Geographic Society
NOAA	-	National Oceanic and Atmospheric Administration
NOAEL	-	No observed adverse effects level
NPDES	-	National Pollutant Discharge Elimination System

ABBREVIATIONS, ACRONYMS, AND SYMBOLS
(Continued)

NPL	-	National Priority List
NTR	-	National Toxics Rule
OCDD	-	Octachlorinated dibenzo-p-dioxin
O&G	-	Oil and gas
ORNL	-	Oak Ridge National Laboratory
OSWER	-	Office of Solid Waste and Emergency Response
OU	-	Operable unit
OU-2	-	Operable Unit 2
PACFLTAVFAC	-	Pacific Fleet Audio-Visual Facility
PAH	-	Polycyclic aromatic hydrocarbon
PARCC	-	Precision, accuracy, representativeness, completeness, and comparability
PCB	-	Polychlorinated biphenyl
PCDD	-	Polychlorinated dibenzo-p-dioxin
PCDF	-	Polychlorinated dibenzofuran
PCE	-	Tetrachloroethylene
PCTR	-	Proposed California Toxics Rule
PDF	-	Probability density function
PEA	-	Preliminary endangerment assessment
PeCDF	-	Pentachlorinated dibenzofuran
PEF	-	Particulate emission factor
PIC	-	Paved invert corrugated iron
POL	-	Petroleum, oil, and lubricant compound
ppb	-	Parts per billion
PRC	-	PRC Environmental Management, Inc.
PRG	-	Preliminary remediation goal
psi	-	Pound per square inch
PVC	-	Polyvinyl chloride
PWC	-	Public Works Center
PWCSFB	-	Public Works Center San Francisco Bay
PWD	-	NAS Alameda Public Works Department
QA	-	Quality assurance
QA/QC	-	Quality assurance and quality control
QAPP	-	Quality assurance project plan
QC	-	Quality control
QCSR	-	Quality control summary report
Radian	-	Radian International LLC
RAO	-	Remedial action order
RBCA	-	Risk-based corrective action
R&D	-	Research and development
RCRA	-	Resource Conservation and Recovery Act
RfC	-	Reference concentration

ABBREVIATIONS, ACRONYMS, AND SYMBOLS
(Continued)

RfD	-	Reference dose
RI	-	Remedial investigation
RI/FS	-	Remedial investigation and feasibility study
RME	-	Reasonable maximum exposure
ROD	-	Record of decision
RPD	-	Relative percent difference
RRF	-	Relative response factor
RWQCB	-	San Francisco Bay Regional Water Quality Control Board
Sanborn	-	Sanborn-Ferris Map Company
SARA	-	Superfund Amendments and Reauthorization Act of 1986
SC	-	Clayey, fine sand
SCAPS	-	Site Characterization Analysis Penetrometer System
SCV	-	Secondary choice value
SDG	-	Sample delivery group
SEE	-	Steam enhanced extraction
SIMA	-	Shore Intermediate Maintenance Activity
SM	-	Silty sand
SMDP	-	Scientific management decision points
SOP	-	Standard operating procedure
SOW	-	Statement of work
SP	-	Sand
SQL	-	Sample quantitation limit
STSC	-	Superfund Technical Support Center
SUF	-	Site use factor
SUPSHIP	-	Supervisor of Shipbuilding, Conversion, and Repair
SVOC	-	Semivolatile organic compound
SW	-	Gravelly sand
SWAT	-	Solid waste water quality assessment test
SWBZ	-	Second water-bearing zone
SWBZL	-	Second water-bearing zone, lower
SWBZU	-	Second water-bearing zone, upper
SWRCB	-	California State Water Resources Control Board
TBC	-	To be considered
TCA	-	Trichloroethane
TCE	-	Trichloroethylene
TCD	-	Toxics Cleanup Division
TCDD	-	Tetrachlorodibenzo-p-dioxin
TCLP	-	Toxicity characteristic leaching procedure
TDS	-	Total dissolved solids
TEF	-	Toxicity equivalency factor
TEQ	-	Toxicity equivalent
THC	-	Total hydrocarbons
TIC	-	Tentatively identified compound
TPH	-	Total petroleum hydrocarbons

EXECUTIVE SUMMARY

The U.S. Navy (Navy) is conducting a remedial investigation (RI) for 25 installation restoration (IR) sites at Alameda Point (formerly Naval Air Station [NAS] Alameda). Currently, the Navy is preparing the property for transfer to the City of Alameda. The City of Alameda is working with the Alameda Reuse and Redevelopment Authority (ARRA) to determine appropriate reuse options for the land.

The Navy received a Remedial Action Order on June 6, 1988, from the California Department of Health Services, now known as the California Department of Toxic Substances Control (DTSC). A total of 23 IR sites at Alameda Point were identified as requiring a remedial investigation/feasibility study (RI/FS) in conformance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Remedial Investigation (RI) activities at the 23 IR sites were conducted between 1988 and 1995. IR Sites 24 and 25 were added to the IR program in 1997 and 1998, respectively. The 25 IR sites were divided into four operable units (OU), OU-1 through OU-4. Dividing sites into OUs is a management method used to group sites with similar environmental issues to facilitate accelerated site investigation and cleanup.

This report presents the results of RI activities conducted at OU-2 IR sites. OU-2 consists of 14 IR sites. Twelve of the 14 IR sites are geographically subdivided into the OU-2 Southeastern (IR Sites 9, 13, 19, 22, and 23), Eastern (IR Sites 3, 4, 11, and 21), and Central (IR Sites 5, 10, and 12) Areas. IR Sites 14 and 25 are geographically isolated from the other 12 sites and are discussed individually in this report.

The investigation was performed in conformance with investigation work plans prepared by the Navy and reviewed by federal and state regulatory agencies. The investigation consisted of initial reviews of records and previous investigations to document past operations in terms of sources of contamination identified, chemicals used, and waste management practices employed. This information was used to identify areas where releases to the environment occurred or had the potential to occur. These areas were addressed in sampling and analysis plans and quality assurance project plans for a number of sequential sampling events. Collection and analysis of soil and groundwater samples proceeded at areas with actual or suspected releases, and at other areas within each of the 14 IR sites within OU-2. In addition, soil and groundwater samples were collected and analyzed in areas outside of OU-2, which were selected (through the application of specific criteria) as being representative of background concentrations for chemicals that were expected to be present within OU-2. Soil and groundwater data were reviewed to ensure that they met data quality objectives identified for the project. Chemicals of potential concern (COPC) were

identified for soils at each IR site, and groundwater COPCs were identified for each of the three areas and for IR Sites 14 and 25. The decision to select groundwater COPCs on an area-wide rather than a site-wide basis was made to ensure that the boundaries between the various IR sites in a given area would not impair delineation of contaminant plumes in the underlying groundwater. Groundwater and soil COPCs were selected by screening chemical data collected for each site (or area) based on COPC selection criteria for Alameda Point. Major chemical classes detected at the OU-2 sites include petroleum hydrocarbons, volatile organic compounds (VOC), semivolatile organic compounds, polychlorinated biphenyls (PCBs), dioxins, pesticides, and metals.

Based on the concentrations of COPCs detected at each site, a human health risk assessment (HHRA) and an ecological risk assessment (ERA) were conducted to select chemicals of concern (COCs) and assess their potential effects on human and ecological receptors. COPCs were selected as COCs if the human health risk assessment results exceeded a 1.0×10^{-6} carcinogenic risk or a non-carcinogenic hazard index (HI) of 1.0, or an ecological hazard quotient (HQ) of 1.0 for a representative ecological receptor specified for Alameda Point.

Two sets of risk calculations are presented in this RI due to technical differences between U.S. Environmental Protection Agency (EPA), EPA Region IX, and California DTSC. The technical differences are in the toxicity reference values, the dermal risk assessment, and exposure pathways. The two sets of risk calculations are based on the following:

- Assumptions based on EPA federal guidance (referred to as the "Navy assumptions" in this report)
- Assumptions based on California DTSC guidance (referred to as the "DTSC assumptions" in this report

Agreement could not be reached on the presentation of a single risk assessment value, but the use of dual risk assessment values has provided supplemental information for risk management decision. Both risk assessments are technically valid and provide pertinent information to risk management decisions.

Soil COCs were detected at relatively low concentrations at all OU-2 IR sites. Chlorinated hydrocarbon plumes were identified in groundwater beneath the OU-2 Central and Eastern Areas, IR Site 9, and IR Site 14. The major bodies of these plumes were found to be limited in size, due to the relatively small groundwater gradient across Alameda Point, especially in the OU-2 Central Area. TPH plumes also were

identified in groundwater at the Southeastern, Eastern, and Central Areas and are shown in figures in this report.

COCs that were identified based on the above risk assessments, were further evaluated based upon information specific to Alameda Point that allows the refinement of some of the more generic assumptions used in the risk assessment process. This supplementary information, which included the identification of ecological and human health risk drivers, fate and transport analysis, and physical/chemical site characteristics, was used to identify chemicals and media for further consideration in a feasibility study (FS) if the site-specific risk was high. The results of these additional analyses were also used to identify sites that were affected solely by petroleum contamination. Such sites are recommended for further consideration under California State's petroleum program.

Based on the above-mentioned analyses, the following recommendations are made for the OU-2 Southeastern, Eastern, and Central areas, and IR Sites 14 and 25. Table ES-1 summarizes the chemicals requiring consideration in an FS. It should be noted that the risks from COCs in groundwater were calculated on an area-wide basis within the three OU-2 sub-areas. However, the localized nature of groundwater plumes make it possible to isolate IR sites that are not affected by unacceptable concentrations of COCs in groundwater.

SOUTHEASTERN AREA

The OU-2 Southeastern Area includes IR Sites 9, 13, 19, 22, and 23. Chlorinated hydrocarbons in groundwater at IR Sites 9 and 19 will be addressed in an FS. In addition, the FS will address petroleum hydrocarbons in the soils and groundwater for IR Site 19. The petroleum hydrocarbons at IR Site 19 are co-mingled with the chlorinated hydrocarbons in groundwater. IR Sites 13, 22, and 23 are recommended for further consideration under the state's petroleum program. The following paragraphs provide additional results from the RI on a site-specific basis.

IR Site 9. Building 410 housed the aircraft paint stripping facility for the then NAS Alameda. Contamination sources included waste solvents that likely entered storm, sanitary, and industrial sewers. RI results indicate that none of the chemicals detected in soils at IR Site 9 pose unacceptable risks to human or ecological receptors. However, groundwater at the site is contaminated with chlorinated VOCs. Therefore, no action is recommended for soils at IR Site 9 and groundwater is recommended for further consideration under an FS.

IR Site 13. The Pacific Coast Oil Works refinery operated in Alameda from 1879 to 1903, and formerly occupied IR Site 13 as well as adjoining IR Sites 19, 22, and 23. RI results indicate that none of the chemicals detected in soils or groundwater at IR Site 13 pose unacceptable risks to human or ecological receptors. However, both soil and groundwater are impacted by petroleum constituents. Therefore, soil and groundwater at IR Site 13 are recommended for further consideration under the state's petroleum program.

IR Site 19. IR Site 19 is located within the northwest corner of IR Site 13 and consists of Yard D13, a former hazardous waste storage yard. Potential contamination sources at this site include waste solvents that were stored at Yard D13. RI results indicate that none of the chemicals detected in IR Site 19 soils pose unacceptable risks to human or ecological receptors. However, soils at the site are impacted with petroleum hydrocarbons. Groundwater at the site is contaminated with both chlorinated VOCs and petroleum hydrocarbons. Therefore, soils and groundwater at IR Site 19 are recommended for further consideration under an FS.

IR Site 22. IR Site 22 consists of the area around Building 547 (a former service station). Based on the RI results, benzene and TPH in soils and groundwater were identified for further consideration at the site. Since contamination at the site is limited to petroleum constituents, soils and groundwater at IR Site 22 are recommended for further evaluation under the state's petroleum program.

IR Site 23. Building 530 was used for missile rework operations and overhauling aviation components. RI results indicate that none of the chemicals detected in soils and groundwater at IR Site 23 pose unacceptable risks to human or ecological receptors. However, groundwater at the site is contaminated with petroleum constituents. Therefore, soil at IR Site 23 is recommended for no action and groundwater is recommended for further consideration under the state's petroleum program.

EASTERN AREA

The OU-2 Eastern Area includes IR Sites 3, 4, 11, and 21. Chlorinated hydrocarbons in groundwater at all of these sites will be addressed in an FS. Additionally, TPH in soils at IR Sites 4 and 11 will be addressed under an FS. The following paragraphs provide additional results from the RI on a site-specific basis.

IR Site 3. IR Site 3 was a fuel storage area for aviation gasoline comprised of five partially buried tanks. RI results indicate that none of the chemicals detected in soils at IR Site 3 pose unacceptable risks to human or ecological receptors. However, groundwater at the site is impacted by TPH contamination north of the former fuel storage tanks and by chlorinated VOCs (originating at IR Site 4) to the south of the former fuel storage tanks. Therefore, no action is recommended for soils at IR Site 3 and groundwater is recommended for further consideration under an FS.

IR Site 4. Building 360 housed specialized production shops for the repair and testing of both jet-turbine and piston-engine aircraft engines. RI results indicate that none of the chemicals detected in soils at IR Site 4 pose unacceptable risks to human or ecological receptors. However, soils at the site are impacted with petroleum hydrocarbons. Groundwater at the site is contaminated with chlorinated VOCs. Therefore, soil and groundwater at IR Site 4 are recommended for further consideration under an FS.

IR Site 11. Building 14 served as the primary site at Alameda Point for aircraft engine repair and testing. RI results indicate that none of the chemicals detected in soils at IR Site 11 pose unacceptable risks to human or ecological receptors. However, soils at the site are impacted with petroleum hydrocarbons. Groundwater at the site is contaminated with chlorinated VOCs. Therefore, soil and groundwater at IR Site 11 are recommended for further consideration under an FS.

IR Site 21. Building 162 initially served as a Navy exchange administrative office, but was primarily used for maintenance operations. RI results indicate that none of the chemicals detected in soils at IR Site 21 pose unacceptable risks to human or ecological receptors. However, groundwater at the site is contaminated with both chlorinated VOCs and petroleum hydrocarbons. Therefore, no action is recommended for soils at IR Site 21 and groundwater is recommended for further consideration under an FS.

CENTRAL AREA

The OU-2 Central Area includes IR Sites 5, 10, and 12. Chlorinated VOCs, other VOCs, and petroleum hydrocarbons in the groundwater at IR Site 5 will be addressed in an FS. In addition, the FS will address cadmium in the soil at IR Site 5. IR Site 10 is recommended for no action, and IR Site 12 is recommended for further consideration under the state's petroleum program. The following paragraphs provide additional results from the RI on a site-specific basis.

IR Site 5. Building 5 housed shops for aircraft component repair and maintenance. RI results indicate that none of the chemicals detected in soils at IR Site 5 pose unacceptable risks to human receptors. However, cadmium in soil may pose ecological risks to terrestrial receptors at IR Site 5. Groundwater at IR Site 5 is contaminated with both chlorinated and petroleum hydrocarbons. Soils and groundwater at IR Site 5 are recommended for further consideration under an FS. The status of the ongoing radiological removal actions at IR Site 5 will be updated in the draft final OU-2 RI report.

IR Site 10. Building 400 operated as a missile rework facility in the mid-1950s. RI results indicate that none of the chemicals detected in soils at IR Site 10 pose unacceptable risks to human or ecological receptors. Ground water contamination in the OU-2 central area is limited to chlorinated plumes detected within and in the immediate vicinity of Building 5 (IR Site 5). No VOCs were detected in groundwater underneath IR Site 10. Radiation removal actions are currently ongoing at Building 400. Based on the RI results, no action is recommended for soils or groundwater at IR Site 10, pending the completion of the ongoing radiological removal actions at Building 400.

IR Site 12. Building 10 housed the former NAS Alameda Power Plant. RI results indicate that none of the chemicals detected in soils at IR Site 12 pose unacceptable risks to human or ecological receptors. However, soils at the site are impacted with petroleum hydrocarbons. Groundwater contamination in the OU-2 central area is limited to chlorinated plumes detected within and in the immediate vicinity of Building 5 (IR Site 5). No VOCs were detected in groundwater underneath IR Site 12. Therefore, soils at Site 12 are recommended for further consideration under the state's petroleum program and groundwater at Site 12 is recommended for no action.

IR SITES 14 AND 25

IR Site 14

IR Site 14 includes the fire training area (FTA), Building 26, former Building 528, and former generation accumulation points (GAPs) 9 and 11. RI results indicate that dioxins and PCBs detected in IR Site 14 soils and chlorinated VOCs detected in the groundwater pose unacceptable risks to human receptors. Soils and groundwater at IR Site 14 will be addressed under an FS.

IR Site 25

The general area of IR Site 25 existed as undeveloped marshlands and tidal flats along the San Francisco Bay fringe prior to the 1920s. IR Site 25 is currently open space primarily covered in grass and used as a baseball field, picnic grounds, and sports courts. RI results indicate that none of the chemicals detected in IR Site 25 groundwater pose unacceptable risks to human or ecological receptors. However, soil is contaminated with polycyclic aromatic hydrocarbons (PAH) and will be addressed under an FS.

In summary, as shown on Table ES-1, a total of 9 out of the 14 OU-2 IR sites were recommended for further evaluation under an FS. Of the remaining sites, one site (IR Site 10) was recommended for no further action, and four sites (IR Sites 12, 13, 22, and 23) were recommended for further evaluation under the state's petroleum program.

TABLE ES-1
SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS
OU-2 IR SITES
ALAMEDA POINT

SITE	SOIL	GROUNDWATER
OU-2 Southeastern Area		
9	No action recommended	Evaluate chlorinated VOCs associated with storm sewers east and west of Building 410 under an FS
13	Evaluate TPH contamination across the site under the state's petroleum program	Evaluate TPH and benzene contamination under the state's petroleum program
19	Evaluate TPH contamination in central and western portions of site adjacent to former refinery and fuel storage tanks under an FS	Evaluate TPH contamination and chlorinated VOCs located primarily in western and central portions of the site under an FS
22	Evaluate TPH and benzene contamination located south of Building 547 under the state's petroleum program	Evaluate TPH and benzene contamination under the state's petroleum program
23	No action recommended	Evaluate TPH and benzene contamination under the state's petroleum program
OU-2 Eastern Area		
3	No action recommended	Evaluate chlorinated VOCs located in plumes located in the southern part of IR Site 3 originating from Building 360 (IR Site 4) and TPH plumes under an FS
4	Evaluate TPH underneath Building 360 and areas outside the building under an FS	Evaluate chlorinated VOCs located in plumes emanating from the north, east and west side of Building 360 under an FS
11	Evaluation of TPH hot spots along south and western sides of Building 14 under an FS	Evaluate chlorinated VOCs located in plumes emanating from northwest corner of Building 14 under an FS
21	No action recommended	Evaluate TPH contamination and chlorinated VOCs located in plumes emanating from southwest corner of Building 162 under an FS
OU-2 Central Area		
5	Evaluate cadmium "hot spots" in shallow soil near the plating shop area, in the south central part of Building 5 under an FS. Further actions may be needed pending the completion of the radiation removal program in Building 5.	Evaluate chloroform, 1,1-DCA, 1,1-DCE, TCE, vinyl chloride, and bis(2-chloroethyl)ether and TPH contamination in groundwater under an FS. Also address potential DNAPLs identified directly beneath and within 100 feet of the footprint of Building 5.
10	No action recommended pending the completion of the radiation removal action in Building 400.	No action recommended since groundwater contamination in the OU-2 Central area is limited to Building 5 (IR Site 5).
12	Evaluate TPH in soil located near the former ASTs and USTs and former fuel lines located around Building 10 under the state's petroleum program.	No action recommended since groundwater contamination in the OU-2 Central area is limited to Building 5 (IR Site 5).
IR Site 14		
14	Evaluate dioxins and PCBs in soils under an FS	Evaluate chlorinated hydrocarbons in groundwater centered in the south-central portion of IR Site 14 under an FS
IR Site 25		
25	Evaluate PAH concentrations in soils distributed across the site under an FS	No action recommended

DNAPL Dense Non Aqueous Phase Liquid
FS Feasibility Study
IR Installation Restoration
PAH Polynuclear Aromatic Hydrocarbons
PCB Polychlorinated Biphenyl
TPH Total Petroleum Hydrocarbons
VOC Volatile Organic Compound

CHAPTER 1
INTRODUCTION

The U.S. Navy (Navy) is conducting a remedial investigation/feasibility study (RI/FS) in conformance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (U.S. Environmental Protection Agency [EPA] 1988a) for 25 installation restoration (IR) sites at Alameda Point (formerly Naval Air Station [NAS] Alameda) in Alameda, California (see Figure 1-1). These 25 IR sites are managed under four operable units (OU). This remedial investigation (RI) report presents the results, conclusions, and recommendations of the RI conducted for 14 of the Alameda Point IR sites that constitute Operable Unit 2 (OU-2). The specific IR sites included in this report are Sites 3, 4, 5, 9, 10, 11, 12, 13, 14, 19, 21, 22, 23, and 25. Twelve of these 14 IR sites have been geographically subdivided into the OU-2 Southeastern, Eastern, and Central areas. Sites 14 and 25 are geographically isolated from the other sites and are discussed separately in this report.

Alameda Point is located on the western end of Alameda Island, which lies on the eastern side of San Francisco Bay adjacent to the City of Oakland. Alameda Point is rectangular, is approximately 2 miles long from east to west and 1 mile wide from north to south, and occupies 1,734 acres of land. The RI for OU-2 was conducted from 1988 to 1998 with oversight from the California Department of Toxic Substances Control (DTSC), the San Francisco Bay Regional Water Quality Control Board (RWQCB), and EPA Region IX.

1.1 OBJECTIVES

This RI report presents the results of investigations undertaken to assess site characteristics and the nature and extent of chemical contamination at 14 IR sites within OU-2. This information was used to assess risks to human health and the environment, that are discussed in Chapter 5 of this report. The RI results also will be used to evaluate remedial alternatives (if required) as part of the feasibility study (FS) for the OU-2 IR sites. Following is a list of specific OU-2 RI objectives:

- Evaluate each OU's geology and hydrogeology
- Assess the nature and extent of chemical contamination and migration at each site

- Produce soil and groundwater data to be used to identify chemicals to be evaluated for further action under a FS
- Present the results of the human health risk assessment (HHRA) and the ecological risk assessment (ERA) for each IR site

1.2 REPORT ORGANIZATION

This report is divided into 11 chapters and 16 appendixes. The remainder of Chapter 1 provides historical background for Alameda Point and describes the OU-2 sites. Chapter 2 provides a discussion of the physical setting, geology, hydrogeology, ecology, future land uses, and soil and groundwater background chemical conditions at Alameda Point. Chapter 3 discusses data quality objectives (DQO) and data validation procedures. Chapter 4 provides a discussion of chemical-, location-, and action-specific applicable or relevant and appropriate requirements (ARAR) for Alameda Point. Chapter 5 provides a description of the HHRA and ERA methodologies used for the RI. Chapters 6 through 10 provide site-specific discussions of the OU-2 Southeastern, Eastern, and Central area sites and IR sites 14 and 25, including RI activities and results, risk assessment results, and conclusions and recommendations. Chapter 11 summarizes the conclusions and recommendations for all of the OU-2 sites.

Appendixes A through P provide supporting documentation and calculations for the RI report. Tables and figures cited within Chapters 1 through 5 of the report can be found at the end of the chapter in which they are described and are numbered consecutively in the order in which they are mentioned; the only exceptions are the geological cross sections that are provided in Appendix A. The locations of tables and figures for Chapters 6 through 10 are indicated in the report outline presented below.

- Volume I: Executive Summary, Chapters 1-5 (text, figures, and tables), References
- Volume II: Chapter 6 (text, tables, and figures)
- Volume III: Chapter 7 (text, tables, and figures)
- Volume IV: Chapter 8 (text, tables, and figures)
- Volume V: Chapters 9, 10, 11 (text, tables, and figures)
- Volume VI: Appendixes A through E
- Volume VII: Appendixes F through P

The rest of this section provides a history of the land that is now known as Alameda Point and a history of the operations performed on the land from the 1800s to the current time. This section also provides details on the hazardous waste generated during past activities at Alameda Point and describes the past disposal and storage practices associated with these wastes.

1.3 INSTALLATION HISTORY

Prior to the construction of Alameda Point, the western tip of Alameda Island was farmed. This area later became an industrial and transit center. Railroad yards and rights-of-way for the Southern Pacific, Central Pacific, and small local railways were built over the area and sloughs to the north. The western terminus for the transcontinental railroad was at the southeastern corner of the area for a short period in 1869. Before 1930, at least two large industrial sites (an oil refinery and a borax processing plant) were located on the western tip of Alameda Island. The oil refinery was located southeast of the borax plant at the southwestern corner of the Main Street and Pacific Street intersection. The borax plant was also located at the southeastern corner of what is now the West Atlantic Avenue and Orion Street intersection (Sanborn-Ferris Map Company [Sanborn] 1897). The U.S. Army (Army) acquired the western tip of Alameda Island from the City of Alameda in 1930 and began construction activities in 1931. In 1936, the Navy acquired title to the land from the Army and began building NAS Alameda (the installation) in response to the military buildup in Europe before World War II (WWII). The construction involved filling the natural tidelands, marshes, and sloughs between the Oakland Inner Harbor and the western tip of Alameda Island. The fill largely consisted of dredge spoils from the surrounding San Francisco Bay and Oakland Inner Harbor. After the United States entered the war in 1941, the Navy acquired more land to the west of the installation. Following the end of the war in 1945, the installation continued its primary mission of providing facilities and support for fleet aviation activities. During its operations as an active naval base, the installation provided berthing for Pacific Fleet ships and was a major center of naval aviation.

Alameda Point was designated for closure in September 1993, and the installation ceased all naval operations in April 1997. The Navy is currently in the process of returning the land to the City of Alameda (referred to as conveyance herein). The Navy and the City of Alameda are working with the Alameda Reuse and Redevelopment Authority (ARRA) to determine appropriate reuse options for the land. The Navy has conducted several environmental investigations at Alameda over time. Table 1-1 presents a summary of all environmental investigations conducted at Alameda Point. These investigations are discussed in more detail in Chapter 2.

The street names at Alameda Point were changed following closure of the base. Table 1-2 provides a cross-reference of old and new street names at the installation.

1.3.1 History of Operations and Chemical Use at the Installation

Activities performed at the installation by the Navy and former tenants are described below.

- **Aircraft Intermediate Maintenance Department (AIMD).** AIMD was responsible for the intermediate repair of aircraft components for transient and tenant aircraft. AIMD used substances such as fuel products and cleaning solvents.

- **Air Operations.** The Navy Public Works Center (PWC) and Naval Aviation Depot Alameda (NADEP) supported a wide variety of air operations across the installation. These operations used substances such as fuel products and cleaning solvents.

- **Waterfront Operations.** The installation operated a deep water port capable of berthing aircraft carriers. The Operations Department, through the Port Services Division, operated and maintained service craft, provided berthing facilities, and provided environmental cleanup services around the piers.

- **Navy Exchange Service Stations.** Two service stations were operated on the installation. At both stations, waste oils were stored in underground tanks and pumped out as needed by a local contractor (Ecology and Environment Inc. [E&E] 1983).

- **Weapons Department.** The Weapons Department was responsible for receiving, issuing, storing, and shipping ammunition, ammunition components, and explosives. The department also operated small arms firing range and saluting battery and coordinated ordnance disposal with the explosive ordnance disposal (EOD) detachment.

- **Supply Department.** The Supply Department was responsible for providing fueling support activities. Fuel products were routinely used by the Supply Department.

- **Pest Control.** PWC used insecticides as well as herbicides for weed control in various areas of the installation. The insecticides chlordane, lindane, and dichlorodiphenyltrichloroethane (DDT) as well as the herbicides telvar, chlorvar, and 2,4-dichlorophenoxyacetic acid (2,4-D) were used for pest control.

The installation and its two largest tenants, PWC and NADEP, supported several activities involving use of substances such as industrial solvents, acids, paint strippers, degreasers, caustic cleaners, and metals from plating operations. Oils, fuels, and asbestos also were used at the installation.

Several other tenants and support units may have used minor amounts of fuel products, pesticides, polychlorinated biphenyls (PCB), and cleaning solvents. These tenants and units are listed below.

- Construction Battalion Unit (CBU) 416
- Commander Naval Air Force, U.S. Pacific Fleet Material Representative
- Defense Property Disposal Office (DPDO)
- Navy Disease Vector Ecology Control Center (DVECC)
- Alameda Detachment, EOD Group One
- Marine Air Group 42
- Marine Barracks
- Naval Air Reserve Unit (NARU)
- Naval PWC - San Francisco Bay
  - Building 114 (public works shops and pesticide shop)
  - Building 6 (transportation shop)
  - Power Plant - Building 10
  - Power Plant - Building 584
- Naval Regional Dental Center (NAVREGDENCEN) Branch Clinic
- Naval Regional Medical Center (NAVREGMEDCEN) Branch Clinic
- Pacific Fleet Audio-Visual Facility (PACFLTAVFAC) Component
- Shore Intermediate Maintenance Activity (SIMA)
- Supervisor of Shipbuilding, Conversion, and Repair (SUPSHIP)

1.3.2 Waste Disposal and Storage Activities

Most industrial wastes generated at the installation were disposed of in one of three locations: (1) the 1943-1956 disposal area (IR Site 1), (2) the West Beach Landfill (IR Site 2), or (3) San Francisco Bay (Figure 1-2). Most of the wastewater generated at the installation was discharged to storm sewers; however, before the early 1970s, an estimated 50,000 pounds per month of accumulated sludges, spent liquid, and solid process material were disposed of at the West Beach Landfill (E&E 1983). After 1972, the wastewater was diverted into either pretreatment facilities (constructed at Buildings 5, 24, 25, 32, and 360) or the East Bay Municipal Utilities District (EBMUD) wastewater system (Figure 1-3). All solid wastes continued to be disposed of at the West Beach Landfill. Details of waste disposal operations at the installation were compiled during the initial assessment study (IAS) conducted under the Navy Assessment and Control of Installation Pollutants (NACIP) program (E&E 1983) and are discussed in detail in the appropriate RI reports for various OUs listed under Section 1.4.

1.4 OPERABLE UNIT DESIGNATIONS

The Navy received a remedial action order (RAO) on June 6, 1988, from the California Department of Health Services, now known as DTSC. A total of 23 sites were identified as needing an RI/FS in conformance with the requirements of CERCLA. Between 1988 and 1995, the Navy conducted

investigations to support the development of RI/FS reports for the 23 IR sites. A 24th site at Alameda Point (between Piers 1 and 2) was added to the list of IR sites in 1997. A 25th site was added to the Installation Restoration Program (IRP) in June 1998 based on the ongoing environmental baseline survey (EBS) described in Chapter 2.

The Base Realignment and Closure (BRAC) Cleanup Team (BCT) developed a comprehensive OU strategy for Alameda Point (BRAC Cleanup Plan [BCP] 1997). This strategy consolidated the initial 23 IR sites and IR Sites 24 and 25 into four OUs as a management tool to accelerate site investigation, cleanup, and reuse. The four OUs and associated IR sites are designated as follows:

- OU-1: IR Sites 6, 7, 8, 15, 16
- OU-2: IR Sites 3, 4, 5, 9, 10, 11, 12, 13, 14, 19, 21, 22, 23, 25
- OU-3: IR Site 1
- OU-4: IR Sites 2, 17, 18, 20, 24

OU-1 sites are relatively small sites with low levels of contamination related to historical petroleum, oil, and lubricant use. These sites are anticipated to be closed with minimal effort and cost and therefore have potential for early conveyance to the community for reuse. OU-2 sites are identified as high reuse potential sites in their current configuration of primary industrial and office buildings and existing manufacturing, maintenance, and repair infrastructures. OU-3 consists of IR Site 1, the former 1943-1956 disposal area and pistol range. OU-4 consists of IR Site 2, and the wetlands and aquatic environments at IR Sites 17, 18, 20, and 24, as shown in Figure 1-2.

The four OUs are organized into four conveyance parcels for conveyance to the community. The following table provides a list of OUs and IR sites currently included in the conveyance parcels.

PARCEL CONVEYANCE	OU	AREA	IR SITE
A*	Not Applicable		
B	1		6, 7, 8, 15, 16
C	3	Northwestern Landfill Area	1
D	2		14
		Central Area	5, 10, 12
		Eastern Area	3, 4, 11, 21
		Southeastern Area	9, 13, 19, 22, 23
			25
E	4		2
			17, 18, 20, 24

* Parcel A includes non-IRP property covered under the EBS program.

The area names were selected based on the geographical locations of the sites and historical Navy activities carried out at the sites within each OU. The number and type of sites within each OU have been revised since the initial IR site designations were assigned.

The following subsections briefly describe the IR sites included in each of the IRP conveyance parcels.

1.4.1 Conveyance Parcel A

Conveyance Parcel A consists of non-IRP property undergoing an EBS. The non-IRP property is currently scheduled to be transferred to the City of Alameda in fall 1999 after completion and signing of a National Environmental Policy Act (NEPA) record of decision (ROD) and completion of economic development and conveyance (EDC) negotiations. Prior to completion of the NEPA ROD, the Navy will prepare a finding of suitability to transfer (FOST) for the non-IRP property, that will be based on the EBS and finding of suitability to lease (FOSL) documents completed for Alameda Point. The FOST will reference the environmental impact statement (EIS) currently being prepared under NEPA and will include a purpose statement, property descriptions, a NEPA compliance statement, and a statement of the environmental condition of property. Also included in the FOST will be any deed restrictions or notifications. Currently the FOST for non-IRP property is scheduled for completion by July 1999.

1.4.2 Conveyance Parcel B

Conveyance Parcel B consists of OU-1 as shown in Figure 1-2. OU-1 includes soil and groundwater matrices at IR Sites 6, 7 (formerly 7A), 8, 15, and 16. The five OU-1 sites are described below.

- IR Site 6: Building 41 - Aircraft Intermediate Maintenance Facility
- IR Site 7: Building 459 - Navy Exchange Service Station
- IR Site 8: Building 114 - Pesticide Storage Area
- IR Site 15: Buildings 301 and 389 - Former Transformer Storage Area
- IR Site 16: Building 338 - C-2 CANS (large shipping containers) Area (equipment receiving, storage, shipping)

The five sites listed above are small sites with relatively low levels of contamination. Chemicals detected in soil and groundwater at OU-1 sites are related to historical petroleum, oil, and lubricant use. Because of the relatively low levels of contamination present, the sites are anticipated to be closed with minimal effort and cost and therefore have potential for early transfer to the community for reuse. The OU-1 sites therefore have a high cleanup priority.

1.4.3 Conveyance Parcel C

Conveyance Parcel C consists of OU-3 as shown in Figure 1-2. OU-3 consists of IR Site 1, a former disposal area and pistol range. The area in Conveyance Parcel C is expected to have long-term reuse potential, possibly as a recreational area, golf course, or hotel.

1.4.4 Conveyance Parcel D

Conveyance Parcel D consists of 14 IR sites as shown in Figure 1-2. Twelve of these sites are included in OU-2 Central, Eastern, and Southeastern areas. This report addresses the 14 IR sites described below.

OU-2 Central Area

- IR Site 5: Building 5 – Naval Air Rework Facility
- IR Site 10: Building 400 – Missile Rework Facility
- IR Site 12: Building 10 – NAS Alameda Power Plant

OU-2 Eastern Area

- IR Site 3: Area 97 – Abandoned Fuel Storage Area
- IR Site 4: Building 360 – Aircraft Engine Facility and Plating Shop
- IR Site 11: Building 14 – Engine Test Cell
- IR Site 21: Building 162 – Ship Fitting and Engine Repair

OU-2 Southeastern Area

- IR Site 9: Building 410 – Paint Stripping Facility
- IR Site 13: Former Oil Refinery
- IR Site 19: Yard D-13 – Hazardous Waste Storage
- IR Site 22: Building 547 – Former Service Station
- IR Site 23: Building 530 – Missile Rework Operations

IR Site 14: Fire Training Area

IR Site 25: Parcel 182

OU-2 IR sites have been identified as high reuse potential sites in their current configuration of primary industrial and office buildings and existing manufacturing, maintenance, and repair infrastructure.

1.4.5 Conveyance Parcel E

Conveyance Parcel E consists of OU-4 as shown in Figure 1-2. OU-4 consists of IR Site 2 (the West Beach Landfill), and the aquatic environments at IR Site 17 (the Seaplane Lagoon), Site 18 (storm sewer system), Site 20 (Oakland Inner Harbor), and Site 24 (Piers 1 and 2). Conveyance Parcel E sites may have a small-scale effect on the ecological system of the San Francisco Bay and Oakland Inner Harbor waters. Land reuse is not applicable at these sites, but economic reuse of the sites is expected. IR Site 17, the Seaplane Lagoon, is slated for reuse as a marina, and IR Sites 20 and 24 are slated for potential reuse as ferry terminals and docking areas.

TABLE 1-1
SUMMARY OF HISTORICAL ENVIRONMENTAL INVESTIGATIONS
OU-2, ALAMEDA POINT
(Page 1 of 4)

Year	Investigation Title	IR Site Investigated [a]	Reference
Pre-IRP Investigations			
1979	Subsurface Fuel Contamination Study	Site 3 - Area 97 Site 11 - Building 410	Kennedy Engineers 1980
1982	Initial Assessment Study	Site 1 - 1943-1956 disposal area Site 2 - West Beach Landfill Site 3 - Area 97 Site 4 - Building 360 Site 11 - Building 14 (fuel lines) Site 13 - Former Oil Refinery Site 14 - Fire Training Area Site 15 - Buildings. 301 and 389 Site 16 - CANS Area Site 17 - Seaplane Lagoon Site 20 - Oakland Inner Harbor Site 24 - Pier 1 and 2 (sediments)	Ecology and Environment 1983
1985	Verification Step/Characterization Study	Site 1 - 1943-1956 disposal area Site 2 - West Beach Landfill Site 3 - Area 97 Site 4 - Building 360	Wahler Associates 1985
1987	Tank Testing Survey	Site 7 - Building 459 Site 22 - Building 547	ERM-West 1987

TABLE 1-1
SUMMARY OF HISTORICAL ENVIRONMENTAL INVESTIGATIONS
OU-2, ALAMEDA POINT
(Page 2 of 4)

Year	Investigation Title	IR Site Investigated [a]	Reference
Year	Investigation Title	IR Site Investigated [a]	Reference
IRP Investigations			
1990	Phases 1 and 2A - Field Investigation and Data Summary Report (CTO 121)	Site 1 - 1943-1956 disposal area Site 2 - West Beach Landfill Site 3 - Area 97 Site 4 - Building 360 Site 9 - Building 410 Site 13 - Former Oil Refinery Site 16 - CANS Area Site 19 - Yard D-13 Site 22 - Building 547 Site 23 - Building 530	PRC and JMM 1993a
1991	Phases 2B and 3 - Field Investigation and Data Summary Report (CTO 121)	Site 4 - Building 360 Site 5 - Building 5 Site 6 - Building 41 Site 7 - Building 459 Site 8 - Building 114 Site 10 - Building 400 Site 11 - Building 14 Site 12 - Building 10 Site 14 - Fire Training Area Site 15 - Buildings 301 and 389 Site 21 - Building 162	PRC and JMM 1992a
1991-1992 1996-1997	Phase 4 - Ecological Assessment	Site 1 - 1943-1956 disposal area Site 2 - West Beach Landfill Site 17 - Seaplane Lagoon Site 20 - Oakland Inner Harbor Other Associated Wetlands	PRC 1996d
1992-1993	Phases 5 and 6 - Solid Waste and Water Quality Assessment	Site 1 - 1943-1956 Disposal Area Site 2 - West Beach Landfill	PRC and MW 1993b

TABLE 1-1
SUMMARY OF HISTORICAL ENVIRONMENTAL INVESTIGATIONS
OU-2, ALAMEDA POINT
(Page 3 of 4)

Year	Investigation Title	IR Site Investigated [a]	Reference
Year	Investigation Title	IRP Site Investigated [a]	Reference
IRP Investigations (Continued)			
1994-1995	Follow-on Field Investigation and Data Transmittal Memorandum (CTO 260)	Site 4 - Building 360 Site 5 - Building 5 Site 8 - Building 114 Site 10 - Building 400 Site 12 - Building 10 Site 14 - Fire Training Area	PRC and MW 1996a
1994-1995	Follow-on Field Investigation and Data Transmittal Memorandum (CTO 280)	Site 1 - 1943-1956 disposal area Site 2 - West Beach Landfill Site 3 - Area 97 Site 4 - Building 360 Site 5 - Building 5 Site 6 - Building 41 Site 7 - Building 459 Site 9 - Building 410 Site 10A - Building 400 Site 11 - Building 14 Site 13 - Former Oil Refinery Site 15 - Buildings 301 and 389 Site 16 - CANS Area Site 19 - Yard D-13 Site 21 - Building 162 Site 22 - Building 547 Site 23 - Building 530	PRC and MW 1996b
1996	Aquifer Testing (CTO 316)	Site 1 – 1943-1956 disposal area Site 2 – West Beach Landfill Site 5 – Building 5 Site 13 – Former Oil Refinery	PRC and MW 1996c

TABLE 1-1
SUMMARY OF HISTORICAL ENVIRONMENTAL INVESTIGATIONS
OU-2, ALAMEDA POINT
(Page 4 of 4)

Year	Investigation Title	IR Site Investigated [a]	Reference
1996-1998	Groundwater Sampling and Tidal Influence Study (CTO 108)	All sites	PRC and MW 1996c PRC and U&A 1997
IRP Investigations (Continued)			
1997	Solvent Plume Definition (CTO 107)	Site 4 – Building 360 Site 5 – Building 5	OGISO Environmental 1997
1998	Solvent Plume Definition (CTO 122)	Site 4 – Building 360 Site 5 – Building 5 Site 14 - Sump	TtEMI and EFW 1998
In Progress	Phase 7 - Comprehensive RI Reports	All sites	NA
In Progress	Phase 8 - Feasibility Study Report	All sites	NA

Notes:

(a) Investigations at Site 18 (the Alameda Point storm sewer system) were conducted as part of investigation activities at various other IR sites listed above.

CANS	Large shipping containers
CTO	Contract Task Order
EFW	Einarson, Fowler, and Watson
ERM-west	Environmental Resources Management West
IRP	Installation Restoration
IR	Installation Program
JMM	James M. Montgomery
MW	Montgomery Watson
NA	Not applicable
PRC	PRC Environmental Management, Inc.
TtEMI	Tetra Tech EM Inc.
U&A	Uribe & Associates

TABLE 1-2
ALAMEDA POINT STREET NAMES
OU-2, ALAMEDA POINT

Former Street Name	Interim Street Name	Current Street Name
A Street	Arizona Street	West Red Line Avenue
B Street	Bainbridge Street	West Essex Drive
C Street	Coral Sea Street	West Midway Avenue
D Street	Dolphin Street	West Ranger Avenue
E Street	Essex Street	West Hope Avenue
F Street	Fulton Street	West Tower Avenue
G Street	Guam Street	West Trident Avenue
H Street	Haylor Street	West Seaplane Avenue
I Street	Ingersoll Street	*Not renamed*
J Street	Jouett Street	*Not renamed*
K Street	Kincaid Street	West Pacific Avenue
L Street	Lexington Street	West Oriskany Avenue
M Street	Midway Street	West Ticonderoga Avenue
N Street	Normandy Street	West Hornet Avenue
1st Avenue	NA	Monarch Street
2nd Avenue	NA	Lexington Street
3rd Avenue	NA	Saratoga Street
4th Avenue	NA	Todd Street
5th Avenue	NA	Pan Am Way (between A and F Streets) Ferry Point Way (between F and N Streets)
6th Avenue	NA	Moonlight Terrace
7th Avenue	NA	Rainbow Court
8th Avenue	NA	Viking Street
9th Avenue	NA	Orion Street
10th Avenue	NA	*Not renamed*
11th Avenue	NA	Skyhawk Street
12th Avenue	NA	Hancock Street
Between B and C Streets	Capt. Dodge Place	West Capt. Dodge Place
Between B and C Streets	Mall Square	West Mall Square
Essex Street east of 5th Avenue	Essex Street	Sunrise Court
Miramar Road	NA	Stardust Place
Glenview	NA	Serenade Place
Alameda Avenue	NA	West Essex Drive
Main Gate	NA	Navy Way

Note:
NA Not applicable

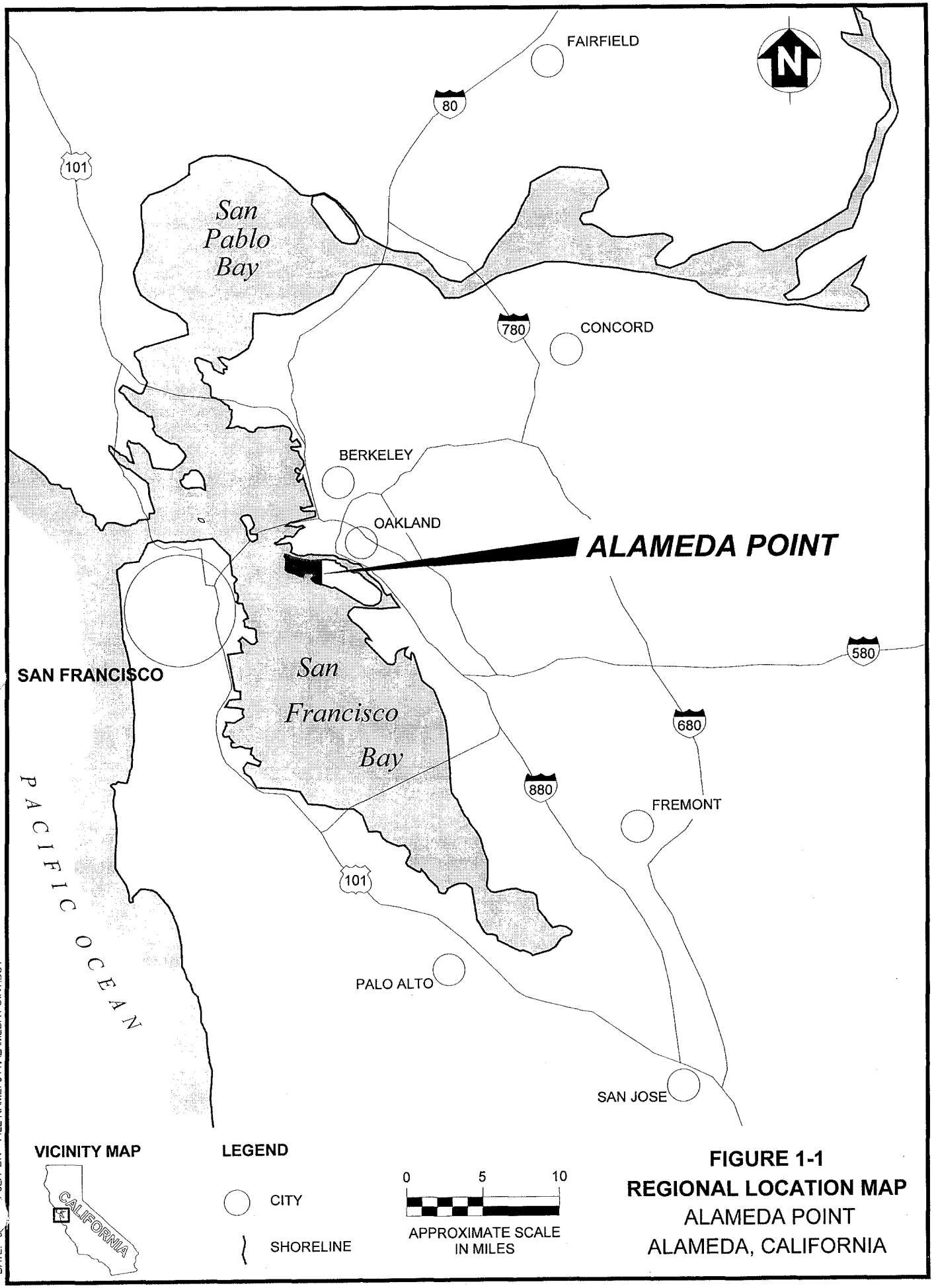

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FIGURE 1-1
REGIONAL LOCATION MAP
ALAMEDA POINT
ALAMEDA, CALIFORNIA

SITE	DESCRIPTION
1	1943–1956 DISPOSAL AREA
2	WEST BEACH LANDFILL
3	ABANDONED FUEL STORAGE AREA
4	BUILDING 360 – AIRCRAFT ENGINE FACILITY
5	BUILDING 5 – AIRCRAFT REWORK FACILITY
6	BUILDING 41 – AIRCRAFT INTERMEDIATE MAINTENANCE FACILITY
7	BUILDING 459 – NAVY EXCHANGE SERVICE STATION
8	BUILDING 114 – PESTICIDE STORAGE AREA
9	BUILDING 410 – PAINT STRIPPING FACILITY
10	BUILDING 400 – MISSILE REWORK OPERATIONS
11	BUILDING 14 – ENGINE TEST CELL
12	BUILDING 10 – POWER PLANT
13	FORMER OIL REFINERY
14	FIRE TRAINING AREA
15	BUILDINGS 301 AND 389 – FORMER TRANSFORMER STORAGE AREA
16	C-2 CANS AREA (SHIPPING CONTAINER STORAGE)
17	SEAPLANE LAGOON
18	STORM SEWER SYSTEM (NOT SHOWN)
19	YARD D-13 – HAZARDOUS WASTE STORAGE
20	OAKLAND INNER HARBOR
21	BUILDINGS 162 AND 14 – SHIP FITTING AND ENGINE REPAIR
22	BUILDING 547 – FORMER SERVICE STATION
23	BUILDING 530 – MISSILE REWORK OPERATIONS
24	PIER 1 AND 2 SEDIMENTS
25	ESTUARY PARK

LEGEND

- 15 — INSTALLATION RESTORATION SITE (IR)
- 145 — ENVIRONMENTAL BASELINE SURVEY PARCEL
- APPROXIMATE EXTENT OF MARSHCRUST
- CONVEYANCE PARCEL A (NON-INSTALLATION RESTORATION PROGRAM PROPERTY)
- CONVEYANCE PARCEL B (OPERABLE UNIT 1)
- CONVEYANCE PARCEL C (OPERABLE UNIT 3)
- CONVEYANCE PARCEL D (OPERABLE UNIT 2)
- CONVEYANCE PARCEL E (OPERABLE UNIT 4)

NOTE: OFFSHORE SAMPLES WILL BE ADDRESSED IN THE OPERABLE UNIT 4 REMEDIAL INVESTIGATION REPORT

250 0 250 500
SCALE: 1" = 500'

FIGURE 1–2
BASE MAP
ALAMEDA POINT
ALAMEDA, CALIFORNIA

OAKLAND INNER HARBOR

SAN FRANCISCO BAY

SEAPLANE LAGOON

RUNWAY 7-25

RUNWAY 13-31

RUNWAY WETLAND

WEST BEACH WETLAND

LEGEND

- ALAMEDA POINT BOUNDARY
- ALAMEDA ANNEX AREA
- 57 BUILDING AND BUILDING NUMBER
- 3 INSTALLATION RESTORATION SITE

SITE	DESCRIPTION
1	1943-1956 DISPOSAL AREA
2	WEST BEACH LANDFILL
3	ABANDONED FUEL STORAGE AREA
4	BUILDING 360 – AIRCRAFT ENGINE FACILITY
5	BUILDING 5 – AIRCRAFT REWORK FACILITY
6	BUILDING 41 – AIRCRAFT INTERMEDIATE MAINTENANCE FACILITY
7	BUILDING 458 – NAVY DRYWARE SERVICE STATION
8	BUILDING 194 – PESTICIDE STORAGE AREA
9	BUILDING 410 – PAINT STRIPPING FACILITY
10	BUILDING 400 – MISSILE REWORK OPERATIONS
11	BUILDING 74 – ENGINE TEST CELL
12	BUILDING 10 – POWER PLANT
13	FORMER OIL REFINERY
14	FIRE TRAINING AREA
15	BUILDINGS 301 & 388 – FORMER TRANSFORMER STORAGE AREA
16	C-2 CAMS AREA (SHIPPING CONTAINER STORAGE)
17	SEAPLANE LAGOON
18	STORM SEWER SYSTEM (NOT SHOWN)
19	YARD D-15 – HAZARDOUS WASTE STORAGE
20	OAKLAND INNER HARBOR
21	BUILDING 162 AND 74 – SHIP FITTING AND ENGINE REPAIR
22	BUILDING 547 – FORMER SERVICE STATION
23	BUILDING 530 – MISSILE REWORK OPERATIONS
24	PIER 1 & 2 SEGMENTS
25	PARCEL WZ

N

150 0 150 300
SCALE: 1" = 300'

FIGURE 1-3
BUILDING AND STREET LOCATION MAP
ALAMEDA POINT
ALAMEDA, CALIFORNIA

CHAPTER 2
INSTALLATION-WIDE SITE DESCRIPTION

This chapter provides information on the physical, geologic, hydrogeologic, and ecological features; future land uses; background chemical concentrations in soil and groundwater at Alameda Point; and ongoing investigations.

2.1 PHYSICAL SETTING

The installation is located on Alameda Island, which lies at the base of a gently westward-sloping plain that extends from the Oakland-Berkeley Hills on the east to the shore of San Francisco Bay on the west. Originally a peninsula, Alameda Island was detached from the mainland in 1902 when a channel was cut linking San Leandro Bay with San Francisco Bay. The northern portion of Alameda Island was formerly tidelands, marshlands, and sloughs adjacent to the historical San Antonio Channel, now known as the Oakland Inner Harbor. Most of the land that is now the installation was created by filling the natural tidelands, marshlands, and sloughs with dredge spoils from the surrounding San Francisco Bay, the Seaplane Lagoon, and the Oakland Inner Harbor (Figure 2-1).

The Bay Area experiences a maritime climate with mild summer and winter temperatures. Prevailing winds in the Bay Area are from the west. Because of the varied topography of the Bay Area, climatic conditions vary considerably throughout the region. Heavy fog occurs on an average of 21 days per year. Rainfall occurs primarily during the months of October through April. The installation averages approximately 18 inches of rainfall per year (Air Traffic Control, NAS Alameda 1992). There are no naturally occurring surface streams or ponds on the installation, so precipitation either returns to the atmosphere by evapotranspiration, runs off in the storm sewer system that discharges to San Francisco Bay, or infiltrates to groundwater.

2.2 GEOLOGY

This section provides an overview of the geology of the San Francisco Bay region, East Bay Margin, and Alameda Point.

2.2.1 San Francisco Bay Regional Geology

The installation is located in the central portion of the eastern side of San Francisco Bay and occupies a depression between two uplifted areas: the Berkeley Hills on the east and the Montara and other mountains on the west. The depression and uplifted areas are formed by two subparallel, active faults: the San Andreas Fault to the west and the Hayward Fault to the east of the bay. The installation and bay are underlain by metamorphosed sandstone, siltstone, shale, graywacke, and igneous bedrock of Jurassic age, all of which form the Franciscan Formation. Alameda Island is underlain by 400 to 500 feet of unconsolidated sediments overlying consolidated Franciscan bedrock (Rogers and Figuers 1991).

The description of the regional East Bay Margin and installation geology in this chapter is based on the work of Trask and Rolston (1951), Radbruch (1957, 1969), Atwater and others (1977), Atwater (1979), Helley and others (1979), Rogers and Figuers (1991), and Sloan (1990, 1992). The work of these investigators was generally regional in nature and was based on a limited number of borings in and around Alameda Point. The installation geology presented in this report is based on interpretation of over 280 monitoring well and piezometer borings, over 340 geotechnical borings, and several hundred cone penetrometer test (CPT) lithologic soundings at Alameda Point. The Quaternary sediments presented in this report consist of five units: from top to bottom, the Bay Mud Formation, the Merritt Sand Formation, the upper unit of the San Antonio Formation, the lower unit of the San Antonio Formation (Yerba Buena Mud), and the Alameda Formation. The nomenclature and interpretation of stratigraphic units presented in this report reflect both data collected during the OU-2 RI and the work of previous investigators. Figure 2-2 provides a stratigraphic column and correlates the units described in this report with those identified by previous investigators. A discussion of the correlation of the stratigraphic units presented in this report with those identified by other investigators is presented below.

The unconsolidated units and the approximate ages of these units are listed below from oldest to youngest (Atwater and others 1977). The equivalent nomenclature used by previous investigators for these units is also listed (Trask and Ralston 1951; Radbruch 1957, 1969; Treasher 1963; and Rogers and Figuers 1991).

- Pliocene to late Pleistocene terrestrial and estuarine deposits: the equivalent unit is the Alameda Formation.
- Late Pleistocene estuarine deposits: the equivalent unit is the lower unit of the San Antonio Formation (including the Yerba Buena Mud).

- Late Pleistocene/Holocene alluvial deposits: the equivalent unit is the upper unit of the San Antonio Formation (including the Posey Formation).
- Late Pleistocene/Holocene eolian deposits: the equivalent unit is the Merritt Sand.
- Holocene estuarine deposits: the equivalent unit is the Young Bay Mud.

The San Antonio Formation is made up of both estuarine (lower unit) and alluvial (upper unit) deposits. The Yerba Buena Mud is the uppermost member of the lower San Antonio Formation estuarine deposits. The terminology "lower unit of the San Antonio Formation" has been adopted to refer to the Yerba Buena Mud in this report. The terminology "upper unit of the San Antonio Formation" has been adopted to refer to the alluvial deposits of the Posey Formation as well as the uppermost alluvial deposits of the San Antonio Formation. The term "Bay Mud" has been adopted to refer to the Holocene estuarine unit previously identified as the Young Bay Mud.

The following lithologic units are of primary concern for the OU-2 RI:

- Late Pleistocene estuarine deposits (the lower unit of the San Antonio Formation, including the Yerba Buena Mud)
- Late Pleistocene/Holocene alluvial deposits (the upper unit of the San Antonio Formation, including the Posey Formation)
- Late Pleistocene/Holocene eolian deposits (the Merritt Sand)
- Holocene estuarine deposits (the Bay Mud)
- Artificial fill

The Bay Mud unit is overlain by artificial fill at Alameda Point. A brief description of the lithologic units of primary concern is presented below.

Late Pleistocene Estuarine Deposits. Estuarine deposits of late Pleistocene age overlie undivided Pliocene/Pleistocene deposits (the Alameda Formation). These estuarine deposits include the Yerba Buena Mud (the lower unit of the San Antonio Formation) (Figure 2-2). The Yerba Buena Mud deposits were emplaced during an interglacial period and represent the "Old Bay Mud," a homogeneous, wide spread stratigraphic marker of the erosional surface of the Alameda Formation developed during glacial epochs. The Yerba Buena Mud was deposited in saline bay water during the Sangamon period when sea levels were about 20 feet higher than at present (Sloan 1990, 1992). The unit is believed to be regional,

underlying San Francisco Bay and the bay margins, including Alameda Point (Rogers and Figuers 1991). The Yerba Buena Mud has been found to extend up to 2 miles inland, underlying downtown Oakland and pinching out near the Hayward Bay Area Rapid Transit (BART) station (Sloan and Aubry 1991). The Yerba Buena Mud in the vicinity of Alameda Point consists of a dark greenish-gray, silty clay. The unit ranges in thickness from 0 feet in Hayward to 125 feet on Yerba Buena Island. The unit is 55 to 90 feet thick at Alameda Point (Atwater and others 1977; Rogers and Figuers 1991).

Late Pleistocene/Holocene Alluvial and Eolian Deposits. Alluvial (the upper unit of the San Antonio Formation and the Posey Formation, where present) and eolian (the Merritt Sand) deposits of late Pleistocene to Holocene age unconformably overlie the late Pleistocene estuarine deposits (the Yerba Buena Mud) (Atwater and others 1977; Rogers and Figuers 1991). The oldest portions of the continental alluvial deposits are approximately equivalent to the uppermost unit of the San Antonio Formation and the younger Posey Formation (where present) identified by Trask and Rolston (1951). The younger portions of the alluvial deposits were emplaced east of the Alameda area and are not discussed further in this report. Subsequent to the emplacement of the late Pleistocene estuarine deposits (the Yerba Buena Mud), the continental alluvial sediments of the upper unit of the San Antonio Formation were deposited in environments ranging from alluvial fans to flood plains, lakes, and beaches. Broad channels were formed within the surface of the upper unit of the San Antonio Formation (Trask and Rolston 1951). The younger Posey Formation, a sandy clay, filled the bottom of the broad channels (Louderback 1939). The Posey Formation cannot be differentiated from the eolian deposits of the Merritt Sand at Alameda Point. At Alameda Point, the upper unit of the San Antonio Formation consists of medium-grained sand containing varying amounts of silt and clay, suggesting deposition in a deltaic environment. The thickness of the upper unit of the San Antonio Formation is 10 to 40 feet in the eastern portion and 7 to at least 72 feet in the central portion of Alameda Point.

The eolian deposits are approximately equivalent to the Merritt Sand identified by Trask and Rolston (1951). The Merritt Sand formed as sand dunes when the bay's water level was much lower than it is today (Atwater and others 1977). The thickness of the Merritt Sand is 8.5 to 56 feet in the southeastern region, 19 to 60 feet in the central region, and 9.5 to 48 feet in the western region of Alameda Point. The eolian Merritt Sand deposits are present at a depth of approximately 45 feet below ground surface (bgs) in the western and central regions and at approximately ground level in the southeastern region of Alameda Point. The Merritt Sand in the vicinity of Alameda Point consists of fine-grained sand to silty sand. Bivalve shells and shell hash are observed in parts of the Merritt Sand, indicating some marine reworking during the most recent sea level rise.

During late Wisconsin time, the Merritt Sand and the upper unit of the San Antonio Formation were eroded by rejuvenated stream systems associated with the retreat of Wisconsin glaciers. One of the streams cut an east-west trending paleochannel, previously identified by Radbruch (1957, 1969), into the Merritt Sand and removed a narrow band of Merritt Sand and alluvial deposits associated with the upper unit of the San Antonio Formation from the western and central regions of Alameda Point. A paleochannel is a stream channel that has eroded through preexisting sediments and has been backfilled with sediments of a different type and age. Because of the former paleochannel, part of the Merritt Sand and the upper unit of the San Antonio Formation are not present at the location of the paleochannel.

Holocene Estuarine Deposits. The Holocene Bay Mud is the youngest naturally occurring unit in the vicinity of Alameda Point. This description of the Holocene Bay Mud at Alameda Point is based on a review of boring logs developed during environmental investigations at Alameda Point. Although it is commonly referred to as "Bay Mud," the unit contains numerous discontinuous sand layers. In some parts of the western region of Alameda Point, the lower portion of the Holocene Bay Mud is composed predominantly of sand. The unit consists of sediments deposited in an estuarine environment and is still being deposited in present-day San Francisco Bay. Bivalves are present in some portions of the unit. In the eastern region of Alameda Point, the uppermost portions of the unit contain abundant plant remains. This area was mapped as tidal flats in an 1856 U.S. Coast and Geodetic Survey as noted Figure 2-1 (Radbruch 1957, 1969). The tidal flat deposits are believed to grade westward into subtidal deposits, and both are considered to be Holocene Bay Mud in this report. The Holocene Bay Mud ranges in thickness from approximately 40 feet in the western region of Alameda Point to 0 foot in the extreme southeastern region. The unit thickens to the west and is up to 100 feet thick in some portions of San Francisco Bay (Trask and Rolston 1951). The Holocene Bay Mud is encountered at approximately 25 feet bgs in the western region of Alameda Point and approximately 5 feet bgs at the eastern region. The depth to the top of the Holocene Bay Mud reflects the historical water levels of the bay before artificial fill operations began.

Artificial Fill. The Holocene Bay Mud is overlain by artificial fill ranging in thickness from 0 to 30 feet over most of Alameda Point. This description of the artificial fill at Alameda Point is based on a review of boring logs developed during environmental investigations at Alameda Point. The artificial fill is present over most of Alameda Point; the exception is the easternmost portion, where the artificial fill is the thinnest. The artificial fill reaches its greatest thickness in the western region and generally decreases in thickness in the eastern region of Alameda Point. The varying thickness of the artificial fill is a result

of natural variation in the depth of the estuary before filling activities, which began in the late 1800s. The artificial fill is therefore thinnest in the 1856 tidal flat area and thickens to the west. The artificial fill consists of dredge spoils from the surrounding San Francisco Bay and the Oakland Inner Harbor. The composition of the artificial fill varies, but it is generally silty sand or sand with minor inclusions of clay or gravel or both. The artificial fill composed of sand is similar in texture to the late Pleistocene/Holocene eolian deposits (the Merritt Sand), which in most cases served as a source for the artificial fill where they underlie the surrounding San Francisco Bay.

Little information is available on the timing of the artificial fill operations. In historical aerial photographs, the fill appears to be placed in linear rows running east and west with the intervening swales filled with water. This filling procedure may have produced a systematic variation in the grain size of the artificial fill, with fine-grained material being deposited closer to the water-filled swales and coarser-grained material being deposited closer to the point at which the hydraulic artificial fill pipe discharged. This potential variation in grain size, if present, could affect shallow groundwater flow in the first water-bearing zone (FWBZ) by creating preferential groundwater flow paths within the coarser-grained material.

2.2.2 East Bay Margin Geology

The sedimentary deposits along the East Bay Margin include the Bay Mud, the Temescal Formation, the Merritt Sand Formation, the Posey Formation, the San Antonio Formation (including the Yerba Buena Mud), and the Alameda Formation (Figures 2-2 through 2-4). The Young Bay Mud crops out along the East Bay Margin. The Temescal Formation crops out onshore on the East Bay Plain. The Merritt Sand and the upper unit of the San Antonio Formation crop out along the East Bay Margin. The Yerba Buena Mud, the lower unit of the San Antonio Formation, pinches out under downtown Oakland, which appears to correlate with the maximum height of interglacial sea levels. Outcrops of the Posey and Alameda Formations are not present along the East Bay Margin or onshore. The formations are often separated by erosional unconformities.

The erosional unconformities have influenced the thickness of the younger formations encountered in the upper 100 feet of the subsurface. Local thickening of the Merritt Sand and the Posey Formation has occurred in valleys previously cut in the underlying formations. The nonmarine Temescal Formation appears to be contemporary with the Merritt Sand. Near Lake Merritt and in the adjoining low hills of the East Bay Plain, the Merritt Sand grades laterally into (or interfingers with) the Temescal Formation. The

lithology is complex and heterogeneous along the inland estuaries as the Merritt Sand interfingers with the Young Bay Mud.

The top of the Merritt Sand crops out approximately 30 feet above sea level on Alameda Island and again south and southwest of Lake Merritt in Oakland. Onshore, the Merritt Sand is partially overlain by surficial terrestrial clays, silts and sands, artificial fill, asphalt, and cement. Perched water tables have been observed within granular materials above the Merritt Sand.

The underlying Posey Formation is usually separated from the Merritt Sand Formation by discontinuous sandy clay lenses. Around Lake Merritt, in the Oakland Inner Harbor, in the Alameda Point pier areas, and in the Oakland Middle Harbor, no distinct clay layers or lenses separate the two formations. It is often difficult to distinguish between the two sand-rich formations in an individual borehole log.

No direct evidence of depositional interconnection between the sands of the Merritt Sand and the Alameda Formation has been identified, as they are separated by both units of the San Antonio Formation. The low-permeability Yerba Buena Mud is between 15 and 44 feet thick along the Oakland bayshore (Rogers and Figuers 1991).

2.2.3 Installation Geology

Based on geologic and hydrogeologic similarities, Alameda Point has been divided into western, central, and southeastern regions (Figure 2-5). The relatively large dimensions of the installation also necessitate separation of otherwise physically similar sites into the western and central regions to preserve a graphic scale for data presentation.

The installation geology presented in this report consists of the upper four Quaternary units identified in Section 2.2.1 plus a surficial layer of artificial fill material. The Alameda Formation was not a focus of the OU-2 RI because the lower unit of the San Antonio Formation (the Yerba Buena Mud) is believed to be an effective and locally continuous hydraulic barrier. The basis for this observation is discussed in later sections. Also, because the Bay Mud Formation at the installation consists of silt and clay with laterally discontinuous layers of silty and clayey sands, the formation is referred to as the Bay Sediments in the rest of this report.

The general installation geology is described below. Figures 2-6 through 2-8 present conceptual geologic cross sections for each region of the installation to provide a point of reference for the following text. Detailed geologic cross sections for the western, central, and southeastern regions of the installation are provided in Appendix A. Site-specific geologic descriptions and cross sections for the OU-2 sites are presented in Chapters 6 through 10.

The differentiation of stratigraphic units presented in both the conceptual and detailed geologic cross sections is based on observed changes in lithology; the color of the lithologic matrix; grain features (frosting, angular, subangular, rounded); the presence of debris, oxidized root channels, and iron oxide staining; the presence of key shell marker beds, buried vegetative surfaces, roots, stems, leaves, old soil surfaces, peat layers, and shell hash; the degree of consolidation; changes in CPT tip resistance and blow counts; and in the case of the historical surface of the Bay Sediments, actual soundings of the bay floor conducted prior to placement of dredge material on shallow tidal flats. Appendix A provides detailed geologic cross sections, a detailed description of the criteria used to distinguish between the stratigraphic units, and a table for each cross section that describes the key features used to distinguish one stratigraphic unit from another.

Artificial fill is present throughout most of the installation and overlies all other late Quaternary sediments. The artificial fill material is composed of various soil and sediment types. The dominant fill type is poorly graded, fine- to medium-grained sand with silt and clay. The artificial fill's thickness ranges from a few feet in the eastern portion of the installation to 20 feet at the western edge of the installation. The artificial fill material is believed to be dredge spoils from the surrounding San Francisco Bay, the Seaplane Lagoon, and the Oakland Inner Harbor. Fill dredged from offshore deposits of Merritt Sand also contains shell hash from rework of beach sands. The artificial fill has been observed to contain layers of less permeable material that may induce contaminants to migrate horizontally. However, no laterally continuous layers are present that would preclude vertical contaminant migration to the top of the Bay Sediments.

The Bay Sediments (Young Bay Mud) consist of silt and gray to black clay with laterally discontinuous, poorly graded, silty and clayey sand layers. A layer with high organic content, which coincides with the surface of buried tidal flats, typically marks the top of the unit throughout most of the installation. However, in the eastern portion of the central region (near IR Site 7) a vegetative debris or peat layer, which coincides with the surface of a buried tidal marshland, is often found at the top of the unit. The

high organic content layer coincides with the buried tidal flats and is a depositional layer of highly decayed organic matter incorporated in the mineral soil; the organic matter is typically plant detritus (that is, decayed stems and leaf skeletons or humus) and algae. This layer is analogous to a detritus layer on the bottom of a pond or lake where the most recently deposited material (for example, leaves) is found at the top of a sediment core, decayed leaf skeletons are found in the middle of a sediment core, and humus incorporated into mineral soil is found at the bottom of a sediment core.

In general, the high organic content layer does not include artificial chemicals such as petroleum hydrocarbons. A database query was run for soil samples that coincide with the high organic content layer at the top of the Bay Sediment Unit (BSU). The purpose of the query was to establish the presence, quantify the frequency of occurrence, and determine the concentration range of naturally occurring and petroleum-derived chemicals within the high organic content layer. The soil boring log description for each sampling interval also was checked to identify presence of petroleum staining or odor, plant debris, peat, or a layer of high organic content.

The results of the query indicated the presence of both naturally occurring and petroleum-based chemicals in the western, central, and southeastern regions of the installation as well as at the location of the former tidal marshlands (Appendix B, Table B-4.1). A comparison of soil boring log descriptions (Appendix B) with individual chemical concentrations indicated that moderate to high chemical concentrations were associated with a release from IR sites or a former oil refinery located in the southeastern region of Alameda Point. It is unclear whether low to moderate semivolatile organic compound (SVOC) and total petroleum hydrocarbon (TPH) concentrations are associated with a petroleum-based release or with natural degradation of plant material. A comparison of the SVOCs detected in soil samples from the high organic content layer and the characteristic SVOCs and SVOC ratios in fuels and motor oil could be conducted. However, the results might be difficult to interpret in that degradation of light-end petroleum compounds and low molecular weight SVOCs may not fully explain the distribution of the SVOCs at Alameda Point. If the presence of SVOCs in the deep soil at the artificial fill and Bay Sediment interface requires a future risk management decision, it may be more beneficial to examine the chemical distribution at and surrounding a known point source and the change in SVOC type and SVOC ratio with distance from the known point source.

The thickness of the Bay Sediments ranges from 10 to 110 feet throughout the installation. However, the Bay Sediments are thin or absent in the southeastern region of the installation. The Bay Sediments were likely deposited in an estuarine environment during the Holocene epoch. The Bay Sediments are laterally

continuous in the western and central regions of the installation, and behave as a local semiconfining layer. This observation is supported by (1) the lack of observed drawdown in the underlying Merritt Sand (second water-bearing zone [SWBZ]) when pumping tests were performed in the artificial fill (FWBZ), (2) the lack of migration of saline water from the SWBZ into the fresh to brackish water of the FWBZ, and (3) the lack of migration of solvents from the base of the artificial fill into the Bay Sediments or of a breakthrough to the underlying Merritt Sand at IR Sites 1 and 5 in the western and central regions of Alameda Point.

Over most of the installation, the Merritt Sand Formation underlies the Bay Sediments. The Merritt Sand outcrops in or underlies a thin artificial fill layer in the southeastern region. The Merritt Sand is composed of brown, fine- to medium-grained, poorly graded sand. The formation is up to 60 feet thick and is thickest in the southern and southeastern portions of the installation. The Merritt Sand Formation is believed to be eolian in origin and was deposited during the late Pleistocene and Holocene epochs (Sloan 1992). The Merritt Sand is laterally continuous throughout the installation except where it is bisected by a major paleochannel. The Merritt Sand does not pose a barrier to groundwater flow or contaminant migration. As discussed in Section 2.2.1, the Merritt Sand is absent at a major paleochannel that crosses the central and western regions of the installation from the northeast to the west. Therefore, channel erosion appears to be the reason for the missing Merritt Sand unit. The trend of the paleochannel is shown in Figure 2-9. The paleochannel was filled with low-permeability silts and clays with discontinuous layers of poorly graded sands associated with the BSU. The poorly graded sands become more continuous and thicker in the western region of the installation. The northeast to west-trending paleochannel is believed to be a barrier to groundwater flow and potential contaminant migration within the SWBZ between the northern and southern portions of the central region of the installation. The paleochannel does not appear to influence groundwater flow or contaminant migration within the FWBZ.

The upper unit of the San Antonio Formation generally underlies the Merritt Sand and consists of interbedded layers of sand and clay with a thickness of up to 70 feet. A persistent layer containing shells and sand is present near the top of the formation. The upper unit of the San Antonio Formation is present over most of the installation but is absent where the paleochannel crosses the central and western regions of the installation. The upper unit of the San Antonio Formation appears to have been deposited in both alluvial and deltaic environments during the late Pleistocene and Holocene epochs. Greenish-gray clay layers within the upper unit of the San Antonio Formation do not appear to be regionally continuous; however, hydraulic data suggest that locally confining layers may be present. Therefore, the upper unit of the San Antonio Formation may not be a regionally significant barrier to potential contaminant migration.

A layer containing organic material (plant debris or peat) is present at the base of the formation.

The lower unit of the San Antonio Formation is the Yerba Buena Mud (Old Bay Mud), which consists of firm, gray, silty clay and clay. This layer of clay deposits was encountered consistently throughout the installation during drilling activities conducted as part of environmental investigations. The Yerba Buena Mud is believed to have formed in a low-energy estuarine environment during the late Pleistocene epoch (Sloan 1992). The total thickness of the Yerba Buena Mud at Alameda Point is reported to range from 55 to 90 feet. The Yerba Buena Mud is believed to be both locally and regionally continuous and a significant barrier to potential contaminant migration. This observation is supported by numerous local and regional boring logs showing an extensive, coherent stratigraphic unit; by the fact that the underlying Alameda Formation yields fresh water while the overlying Merritt Sand and upper unit of the San Antonio Formation yield saline to hypersaline water (Hickenbottom 1988); and by pumping tests performed in the Alameda Formation during which no drawdown was observed in the overlying Merritt Sand or upper unit of the San Antonio Formation (Hydro-Search, Inc. [HSI] 1977). Figure 2-10 presents the extent of the Yerba Buena Mud in the vicinity of Alameda Point; a more regionally extensive view of the Yerba Buena Mud is provided by Rogers and Figuers (1991). The paleochannel that crosses Alameda Point has partially eroded into the Yerba Buena Mud but does not bisect the unit. The paleochannel was backfilled with clays and silts of the Young Bay Mud.

2.3 INSTALLATION HYDROGEOLOGY

As described in Section 2.2.3, the installation has been divided into western, central, and southeastern regions based on geologic and hydrogeologic similarities. In the western and central regions of the installation, the five geologic units form four hydrogeologic units: from top to bottom, the FWBZ in the artificial fill layer, the BSU, the SWBZ in the Merritt Sand unit and upper San Antonio Formation, and the Yerba Buena Mud aquitard. In the southeastern region, only two hydrogeologic units have been identified because of the discontinuous nature or absence of the semiconfining BSU: the FWBZ in the Merritt Sand unit and the Yerba Buena Mud aquitard. The FWBZ in the western and central regions is found in the artificial fill overlying the BSU and is connected to the FWBZ in the southeastern region by a thin layer of artificial fill overlying the BSU. The BSU pinches out along an approximately east-to-west-trending line under IR Site 3 along Atlantic Avenue (Figure 2-11). The FWBZ in the southeastern region is found in both the thin layer of artificial fill and the Merritt Sand unit. In the absence of a confining layer, the entire Merritt Sand unit in the southeastern region is identified as the FWBZ. The SWBZ is not present in the southeastern region because of the absence of the semiconfining BSU.

Figure 2-11 provides a graphic correlation between the geologic and hydrogeologic units at the installation. Hydrogeology specific to the western, central, and southeastern regions is discussed below.

During past groundwater monitoring events, the groundwater piezometric surface measured in wells screened in the upper and lower intervals of the FWBZ differed by up to 2 feet in some areas. This difference was noted in all three regions of the installation. Because of this difference in the piezometric surface and the absence of a discernible confining layer, the FWBZ has been formally divided into two separate hydrogeologic intervals: the FWBZ upper (FWBZU) and the FWBZ lower (FWBZL). The difference in piezometric head between the upper and lower intervals of the FWBZ suggests the presence of a vertical gradient between the two intervals. A vertical gradient is determined by taking the difference in piezometric head between two hydrostratigraphic units and dividing it by the thickness of the intervening unit. The orientation of the vertical gradient (up or down) varies throughout the year and is primarily influenced by precipitation and evapotranspiration.

In the western and central regions, most of the FWBZ is in the artificial fill layer; however, the FWBZL may extend into the BSU where a silty or clayey sand layer is present. In the southeastern region, the FWBZU is composed of artificial fill and the poorly graded upper Merritt Sand unit, while the FWBZL is composed of the well-graded lower Merritt Sand unit and the upper San Antonio Formation.

The SWBZ has also been divided into two separate hydrogeologic intervals: the SWBZ upper (SWBZU) and the SWBZ lower (SWBZL). The difference in piezometric head between the upper and lower intervals of the SWBZ suggests the presence of an upward vertical gradient from the upper unit of the San Antonio Formation to the Merritt Sand unit. Most of the SWBZ is in the Merritt Sand unit, while the SWBZL extends into the interbedded silty and clayey sands of the upper San Antonio Formation.

Use of the phrase "hydrogeologic intervals" does not mean that a barrier to flow is present. The phrase simply reflects the fact that the potentiometric heads of the "intervals" are different. This difference in potentiometric head may be related to a local restriction of flow involving compression of sediments or alternating grading sequences of sediments during deposition. Therefore, the division of the FWBZ and SWBZ into upper and lower intervals is relevant only to the discussion of groundwater hydraulics. The discussion of chemical data in Chapters 6 through 10 assumes that sufficient communication (flow) exists between the upper and lower intervals for contaminant migration to occur; although the magnitude and direction of flow may change on a seasonal basis.

The following subsections provide details on the western, central, and southeastern regions of Alameda Point.

2.3.1 Western and Central Region Hydrogeology

Four hydrogeologic units have been identified in the western and central regions (Figure 2-11). Figure 2-12 presents a conceptual hydrogeologic model for the western and central regions of the installation. The FWBZ is an unconfined (water table) aquifer composed of artificial fill material. At locations in the central region, the upper portion of the BSU contains silty and clayey sand layers. Therefore, the FWBZL may extend into the sand layers of the upper BSU (Figure 2-11). The FWBZ is found at approximately 6 feet bgs. The saturated thickness of the FWBZ ranges from less than 10 feet in the central region to over 30 feet in the western region.

The BSU underlies the FWBZ and is generally composed of silt and clay. In the western region, the upper portion of the BSU consists entirely of silt and clay. The distinction between the FWBZ and the BSU is clear in this region. The BSU appears to be less distinct in the central region, where the upper portion of the BSU consists of interbedded silt and sand. In the northern portion of the central region, the BSU is 20 to 100 feet thick and consists mainly of silt and clay.

The SWBZ in the western and central regions is confined and composed of the lower portion of the BSU, the Merritt Sand Formation (where present), and the upper unit of the San Antonio Formation. In the western region, the Merritt Sand Formation and the upper unit of the San Antonio Formation are not laterally continuous. However, the lower portion of the BSU, which consists mainly of poorly graded sand, forms the SWBZ where the Merritt Sand and the upper unit of the San Antonio Formation are absent. The SWBZ varies in thickness from 0 to 50 feet as a result of erosion associated with the northeast-to-west-trending paleochannel.

The SWBZ is underlain by the Yerba Buena Mud aquitard, which appears to be thick and continuous throughout the entire installation. The Yerba Buena Mud aquitard is believed to be an effective hydraulic barrier between the SWBZ and the underlying Alameda Formation (Figures 2-2 and 2-4). A discussion supporting this statement is presented in Section 2.2.3. The Yerba Buena Mud aquitard is 55 to 90 feet thick. There is no connection between the shallow aquifer systems on Alameda Island and the Oakland mainland because Oakland Inner Harbor bisects the Merritt Sand unit. The Merritt Sand unit on Alameda Island is hydraulically isolated from mainland aquifers.

2.3.2 Southeastern Region Hydrogeology

Two hydrogeologic units have been identified in the southeastern region of the installation: the FWBZ and the Yerba Buena Mud aquitard. The FWBZ is composed of artificial fill material, the Merritt Sand, and the upper unit of the San Antonio Formation. Because the BSU is absent in most of the southeastern region, the FWBZ is unconfined (Figure 2-11). Figure 2-13 presents a conceptual hydrogeologic model for the southeastern region of the installation. The FWBZ is found at approximately 6 feet bgs. The FWBZ is up to 100 feet thick in the southeastern region. The Yerba Buena Mud aquitard underlying the FWBZ is believed to be an effective hydraulic barrier between the FWBZ and the underlying Alameda Formation. A discussion supporting this statement is presented in Section 2.2.3. The Yerba Buena Mud aquitard is 55 to 80 feet thick. There is no connection between the shallow aquifer systems on Alameda Island and the Oakland mainland because the Oakland Inner Harbor bisects the Merritt Sand unit. The Merritt Sand unit on Alameda Island is hydraulically isolated from mainland aquifers.

2.3.3 Groundwater Hydraulics

Groundwater hydraulics for the western, central, and southeastern regions are discussed below.

2.3.3.1 Western and Central Region Hydraulics

The FWBZ in the western and central regions is an unconfined (water table) aquifer composed of artificial fill. The depth to groundwater ranges from 2 to 8 feet bgs and averages 3 to 5 feet bgs. The elevation of the water table in the FWBZ ranges from 3 to 12 feet mean lower low water (MLLW) and is typically 6 to 9 feet MLLW. Figures 2-14a through 2-14c present graphic interpretations of the potentiometric surface for the FWBZU and FWBZL in the western and central regions based on groundwater elevations measured in April 1998.

Aquifer pumping tests and slug tests were performed in the FWBZ, BSU, and SWBZ. Table 2-1 summarizes the test results for each hydrostratigraphic unit in each region and identifies the method used to determine each hydraulic parameter. A complete discussion of the results of the aquifer pumping test program is presented in the "Technical Memorandum Aquifer Test Data Analysis" (PRC Environmental Management [PRC] and Montgomery Watson Consulting Engineers [MW] 1996c). Hydraulic conductivity in the FWBZ varies throughout the western and central regions. Aquifer testing in the

western and central regions has yielded hydraulic conductivity value ranges of 1.06×10^{-2} to 4.13×10^{-2} foot per minute (ft/min) and 6.30×10^{-3} to 1.46×10^{-2} ft/min, respectively. Hydraulic conductivity is also believed to vary across the depth of the unconfined aquifer because of the stratification of the fill material. Aquifer storage coefficients ranged from 0.0013 to 0.012 (unitless) and the specific yield ranged from 0.005 to 0.23 (unitless).

Groundwater flow in the FWBZ is horizontal. The groundwater generally flows radially from the central portions of each region toward San Francisco Bay, the Oakland Inner Harbor, and the Seaplane Lagoon. Groundwater flow immediately adjacent to the northern side of the lagoon is altered by a sheet pile wall located along the northern edge of the Seaplane Lagoon. The presence of the sheet pile wall has resulted in mounding of groundwater north of the Seaplane Lagoon. Groundwater flow is impacted locally near industrial buildings by preferential flow paths such as storm water drains and underground utility conveyance structures. Shallow groundwater in the vicinity of IR Site 7 actually flows inland rather than westward towards San Francisco Bay, in part because of a drainage ditch east of the site. This phenomenon is limited to IR Site 7 because of the presence of the drainage ditch. Water levels in the vicinity of industrial buildings indicate localized regions of groundwater mounding or groundwater sinks. Groundwater recharge to the FWBZ is attributed to vertical infiltration from precipitation; horticultural irrigation; and leaking water supply, sanitary sewer, and storm sewer pipes. Tidal inundation of wetland areas and storm water conveyance lines may also contribute recharge to the FWBZ.

The FWBZ is tidally influenced on the northern, western, and southern sides of Alameda Point. Tidal influence studies indicate the region of influence extends approximately 250 to 300 feet inland on the northern and southern sides of Alameda Island and approximately 1,000 to 1,500 feet inland on the west side. Diurnal tidal fluctuations measured in the FWBZ range from 0.1 to 4 feet (PRC 1997a).

Vertical hydraulic communication between the FWBZ and SWBZ through the BSU is believed to be minimal. This observation is supported by the following factors:

- Numerous boring logs showing an extensive, coherent clay member in the upper BSU
- Lack of observed drawdown in the underlying Merritt Sand (SWBZ) when pumping tests were performed in the artificial fill (FWBZ)
- Lack of migration of saline water from the SWBZ into the fresh to brackish water of the FWBZ

- Lack of migration of solvents from the base of the artificial fill into the Bay Sediments and of breakthrough to the underlying Merritt Sand at IR Sites 1 and 5

Water level data collected from clustered wells generally show a difference of 1 to 2 feet in water levels between the two water-bearing zones. Clustered wells consist of monitoring wells located in close proximity to one another and screened in different water-bearing zones or intervals within a water-bearing zone. Local vertical hydraulic gradients between the FWBZ and SWBZ determined at various locations in the western and central regions ranged from 0.01 to 0.02 foot per foot (ft/ft). The vertical gradient varied from upward to downward on a seasonal basis, depending on the most recent precipitation event. The FWBZ responds to precipitation events while the SWBZ does not because of the presence of the BSU. Local horizontal gradients calculated at similar locations throughout the year ranged from 0.001 to 0.003 ft/ft in both the FWBZ and SWBZ. A horizontal gradient is determined by taking the difference in piezometric head between two wells screened in the same hydrostratigraphic unit and dividing it by the horizontal distance between the two wells. Hydraulic conductivity values for the silty clays of the BSU determined using slug tests are typically on the order of 7.1×10^{-5} ft/min, while hydraulic conductivity values for the FWBZ determined using aquifer tests are on the order of 6.3×10^{-3} ft/min. Darcy's Law implies that the horizontal component of flow (6.3×10^{-6} ft/min [0.001 ft/ft multiplied by 6.3×10^{-3} ft/min]) is generally an order of magnitude greater than the vertical component (7.1×10^{-7} ft/min [0.01 ft/ft multiplied by 7.1×10^{-5} ft/min]). Therefore, flow is generally dominated by the horizontal component.

The SWBZ appears to be a confined or semiconfined aquifer and is composed of the silty sands within the lower portion of the BSU, the Merritt Sand unit, and the upper unit of the San Antonio Formation. The potentiometric elevation of the SWBZ ranges from 3 to 9 feet MLLW. Figure 2-14d presents a graphic interpretation of the potentiometric surface for the upper interval of the SWBZ throughout Alameda Point based on groundwater elevations measured in April 1998. A potentiometric map for the lower interval of the SWBZ was not generated because of the limited number of wells available for collection of relevant data.

Multiple slug tests performed in wells screened in the SWBZ of the western region indicate that the hydraulic conductivity of the SWBZ ranges from 1.22×10^{-3} to 3.7×10^{-3} ft/min.

The Merritt Sand is underlain by the upper and lower units of the San Antonio Formation. The lower unit, the Yerba Buena Mud, is believed to be both locally and regionally continuous and a significant barrier to potential contaminant migration. This observation is supported by numerous local and regional

boring logs showing an extensive, coherent stratigraphic unit; by the fact that the underlying Alameda Formation yields fresh water while the overlying Merritt Sand and upper unit of the San Antonio Formation yield saline to hypersaline water (Hickenbottom 1988); and by pumping tests performed in the Alameda Formation during which no drawdown was observed in the overlying Merritt Sand or upper unit of the San Antonio Formation (HSI 1977).

Recharge of the SWBZ is mainly by lateral flow (through the Merritt Sand) from upgradient areas on Alameda Island. Another source of recharge may be the upper unit of the San Antonio Formation, although the thickness and discontinuity of the water-bearing zones within the upper unit of the San Antonio Formation would preclude a significant contribution. The sources of recharge for the Merritt Sand unit are precipitation; irrigation; and water supply, sanitary sewer, and storm sewer pipe leakage. The SWBZ is believed to discharge through lateral groundwater flow to San Francisco Bay, the Oakland Inner Harbor, and the Seaplane Lagoon.

2.3.3.2 Southeastern Region Hydraulics

The shallow aquifer system in the southeastern region consists of only the unconfined FWBZ. The FWBZ is up to 100 feet thick and is composed of a thin layer of artificial fill and the Merritt Sand unit. The FWBZ in the southeastern region is a much more substantial hydrogeologic unit than the FWBZ in the other regions of Alameda Point. The depth to groundwater in the southeastern region FWBZ is approximately 2 to 8 feet bgs, similar to that in the FWBZ in the other regions of Alameda Point. The FWBZ (Merritt Sand unit) in the southeastern region is hydraulically connected to the FWBZ (artificial fill layer) in the central region by a thin layer of artificial fill placed on top of the old beach surface (Merritt Sand unit). The FWBZ (Merritt Sand unit) in the central region and the FWBZ (Merritt Sand unit) in the southeastern region are in fact the same hydrogeologic unit, although they are present at different depth intervals. The elevation of the water table in the southeastern region FWBZ ranges from 3 to 12 feet MLLW and is typically 6 to 9 feet MLLW. Figures 2-14e and 2-14f present graphic interpretations of the potentiometric surface for the upper and lower intervals, respectively, of the FWBZ in the southeastern region based on groundwater elevations measured in April 1998.

Aquifer pumping tests and slug tests were performed in the FWBZ, BSU, and SWBZ (PRC 1995c; PRC and MW 1996c). Table 2-1 summarizes the test results for each hydrostratigraphic unit in each region and identifies the method used to determine each hydraulic parameter. A complete discussion of the results of the aquifer pumping test program is presented in the "Technical Memorandum Aquifer Test

Data Analysis" (PRC and MW 1996c). Hydraulic conductivity in the FWBZ varies throughout the southeastern region. Aquifer testing has yielded hydraulic conductivity value ranges of 1.87×10^{-3} to 5.91×10^{-3} ft/min. Hydraulic conductivity is also believed to vary across the depth of the unconfined aquifer because of the stratification of the sedimentary deposits. Aquifer storage coefficients ranged from 0.0004 to 0.0012 (unitless), and the specific yield of the water-bearing zone ranged from 0.035 to 0.22 (unitless).

Groundwater in the FWBZ generally flows from the east or northeast inland areas to the west or southwest toward the Seaplane Lagoon and San Francisco Bay. Groundwater flow is impacted locally near industrial buildings by preferential flow paths such as storm water drains and underground utility trenches. Water levels in the vicinity of industrial buildings indicate localized regions of groundwater mounding or groundwater sinks. Groundwater recharge to the FWBZ is mainly attributed to vertical infiltration from precipitation; horticultural irrigation; and leaking water supply, sanitary sewer, and storm sewer pipes both at Alameda Point and upgradient of Alameda Island. Tidal inundation of storm water conveyance lines may also contribute recharge to the FWBZ. The storm water conveyance lines act as potential groundwater "sinks" during low tides when the gradient is toward these lines.

The FWBZ is tidally influenced immediately adjacent to the Seaplane Lagoon and San Francisco Bay. Tidal influence studies indicate that the region of influence extends approximately 1,300 feet inland on the western side of the region adjacent to the Seaplane Lagoon. Diurnal tidal fluctuations measured in the FWBZ range from 0.25 to 1 foot (PRC 1997a; Tetra Tech EM, Inc. [TtEMI] 1997b).

The Merritt Sand is underlain by the upper and lower units of the San Antonio Formation. The lower unit, the Yerba Buena Mud, is believed to be both locally and regionally continuous and a significant barrier to potential contaminant migration. This observation is supported by numerous local and regional boring logs showing an extensive, coherent stratigraphic unit; by the fact that the underlying Alameda Formation yields fresh water while the overlying Merritt Sand and upper unit of the San Antonio Formation yield saline to hypersaline water (Hickenbottom 1988); and by pumping tests performed in the Alameda Formation during which no drawdown was observed in the overlying Merritt Sand or upper unit of the San Antonio Formation (HSI 1977).

2.3.4 Seawater Intrusion

As described in Sections 2.1 and 2.2, Alameda Point was developed by placing hydraulic fill material directly into San Francisco Bay. Therefore, the water in the pores of the FWBZ was originally seawater.

Over time, freshwater recharge has diluted the brackish pore water and developed the present freshwater lens in the FWBZ. At the same time, the process of seawater intrusion is occurring at those locations where freshwater recharge is not occurring. Seawater intrusion is a natural consequence of climatic variations or of any phenomena that affect the water budget in a shallow coastal aquifer such as the Merritt Sand unit. A saltwater wedge typical of coastal aquifers has formed in the FWBZ around the perimeter of Alameda Point, especially in the Merritt Sand unit of the southeastern region of the installation. The landward extent of saltwater intrusion in the FWBZU around the perimeter of the installation is approximately 250 feet, while the landward extent of saltwater intrusion in the FWBZL of the southeastern region of the installation is approximately 1,500 feet.

Groundwater in the FWBZ at Alameda Point consists of a thin lens of fresh water (0 to 20 feet bgs) that floats on brackish to saline water. The interface between the fresh water and the brackish to saline water across the western and central regions of Alameda Point appear to be abrupt and coincides with the contact between the artificial fill and BSU (approximately 20 feet bgs), where the BSU is present. Below the contact between the artificial fill and BSU, groundwater is defined as brackish to saline. Figures 2-15 and 2-16 show the approximate extent of fresh water in the FWBZ and SWBZ, respectively, at Alameda Point based on a total dissolved solids (TDS) concentration below 3,000 milligrams per liter (mg/L). The value of 3,000 mg/L TDS (RWQCB 1995) is a point of departure for differentiation of fresh and brackish to saline groundwater. The interface between fresh and brackish to saline water is generally 30 to 40 feet bgs in the southeastern region; an exact depth cannot be provided because the interface slopes from mean sea level to the base of the Merritt Sand unit inland on Alameda Island. The lower unit of the San Antonio Formation (the Yerba Buena Mud) separates the shallow, brackish to saline groundwater from deeper, regional freshwater aquifers across the east bay region and at Alameda Point.

A groundwater beneficial use technical memorandum for Alameda Point has been prepared which describes the quality and beneficial use of the groundwater resource for Alameda Point (TtEMI 1998a). The technical memorandum focuses on applicable water quality policies and regulations, the rationale for and assessment of groundwater quality, the feasibility of using the groundwater resource, and the determination of the probable beneficial use of the groundwater resource at Alameda Point. The document is currently being revised to reflect EPA groundwater classification and use scenarios.

2.3.5 Existing Uses of Groundwater

Nine state-registered wells are screened in the unconfined Merritt Sand unit east of Alameda Point. The registered wells are located in the neighborhood south of Atlantic Avenue and west of Webster Street. Unregistered, private irrigation wells screened in the unconfined Merritt Sand unit and the Alameda Formation are also located in the residential community east of Alameda Point. All the neighborhood wells are hydraulically upgradient of Alameda Point. Many of the unregistered wells screened in the Merritt Sand aquifer were installed by private landowners to obtain water for lawn and horticultural irrigation during periods of drought. The irrigation wells are known to be in current use for lawn irrigation within the community. The irrigation wells were installed in accordance with historical well construction standards prior to the enactment of current Alameda County well construction standards. Current Alameda County standards prohibit screening of municipal or domestic water supply wells in the unconfined Merritt Sand unit.

Three wells are screened in the confined Alameda Formation. Two of the wells are in operation; one of the wells has been closed. Of the two operational wells, one is near the intersection of what is now Pan Am Way and West Red Line Avenue on Alameda Point. The other operational well is near the intersection of 5th Street and Pacific Avenue east of Alameda Point. The wells screened in the confined Alameda Formation are used for irrigation purposes. Pumping test and geochemical data indicate that no connection exists between the Merritt Sand unit and the Alameda Formation.

2.4 ECOLOGY

This section summarizes the ecology of the Bay Area and Alameda Point. It provides descriptions of the ecological regions, soil types, habitats and dominant species, and special status species found in the Bay Area and at Alameda Point.

2.4.1 Regional Ecology

The Bay Area is situated in the California coastal chaparral forest and scrub province of the Mediterranean division and includes the discontinuous coastal plains. The coastal province has a more moderate climate than the interior and receives some moisture from fog in summer. The coastal plains are characterized by sagebrush and grassland communities. Exposed coastal areas support desert-like

shrub communities called coastal scrub; such communities are dominated by coyote bush, California sagebrush, and bush lupine. Most of the coastal plains have been converted to urban use, which is evident in the Bay Area. The area continues to be a major resource and migration route for both aquatic and terrestrial birds (Bailey 1995).

2.4.2 Soil Types

The soil at Alameda Point is described by the U.S. Department of Agriculture (USDA) Soil Conservation Service as consisting of Xeropsamments, which is a very permeable, sandy fill material dredged from old beach areas (USDA 1981). Slow runoff is associated with this soil type, and the potential for surface water erosion is low; however, the potential for wind erosion is high. OU-2 soils consist of a mosaic of Xeropsamments, Xerorthents, and Urban Land. Xerorthents is a relatively impermeable, clayey fill material with large pieces of asphalt, concrete, and sandstone and fragments of glass making up the soil profile. Slow runoff is associated with this soil type, and the potential for erosion is low. Urban Land is characterized as mainly heterogeneous fill material found in areas covered by buildings, roads, parking lots, and other urban structures. The soil in the wetlands of Alameda Point also consists of Xeropsamments, which is a soil type that does not meet the indicator criteria for hydric soils (U.S. Army Corps of Engineers [USACE] 1989). There may be inclusions within the Xeropsamments that exhibit hydric soil conditions because of topography (depressions), but most soil at Alameda Point is recent, unweathered, mineralized sand with low clay content. In general, these characteristics do not indicate hydric soil conditions.

2.4.3 Habitat Types and Dominant Species

Alameda Point, including contiguous and noncontiguous properties, such as constructed breakwaters, contains nine terrestrial and aquatic wildlife habitats. Major habitat types currently present at Alameda Point are described below and presented in Figure 2-17. Site reconnaissance visits to identify habitats were conducted by PRC in 1995 and 1997. Observations made during the site reconnaissance visits as well as literature sources were used to characterize the following major habitats at Alameda Point.

Open Water Areas. Alameda Point is bordered to the north, west, and south by San Francisco Bay aquatic habitats. The primary aquatic areas include the Seaplane Lagoon and Oakland Inner Harbor as well as other areas known as the Western Bayside to the west and the Breakwater Beach area to the south (see Figure 2-18). Phytoplankton (dominated by diatoms and dinoflagellates) and green and blue-green

algae are the dominant plants found in the open water habitat of San Francisco Bay. Red algae are dominant in the benthic zone and provide forage for herbivorous invertebrates and fish (Kozloff 1993). Zooplankton, filter-feeding invertebrates, and fish consume the phytoplankton. Dominant zooplankton groups include rotifers and crustaceans such as cladocera (water fleas), copepods, and opossum shrimp. Dominant filter-feeding invertebrates include mussels, clams, shrimp, scallops, barnacles, hydrozoa, and invertebrate larvae (Carefoot 1977). Dominant benthic invertebrates in the areas surrounding Alameda Point include amphipods, bivalves, polychaete worms, and crabs. Dominant filter-feeding fish species include anchovies, herring, and larval fishes. The dominant small carnivorous fish include gobies, sculpins, and surfperches. The dominant large carnivorous fish include striped bass, halibut, rock fish, and starry flounder (McConnaughey and McConnaughey 1985). The open water areas also provide habitat for piscivorous birds and shorebirds, such as pelicans, herons, and terns, and for carnivorous marine mammals such as sea lions and seals. The larger fish and bird species, however, are migratory and have large home ranges.

Estuarine Intertidal Emergent Wetlands. There are two primary wetland habitats at Alameda Point: the West Beach Landfill Wetland and the Runway Area Wetland. Dominant wetland vegetation includes pickleweed, saltgrass, seaside trefoil, and brass buttons. Dominant animal species occurring in the wetlands include American avocets, black-necked stilts, and Caspian terns.

Paved Runway Areas. The runway tarmac provides an important nesting habitat for the California least tern. Otherwise, paved areas provide marginal habitat for most plant species and therefore provide minimal cover and foraging habitat for most animal species.

Non-native Grassland. This habitat dominates the runway area and the western portion of Alameda Point. Dominant plants include ryegrass, yellow sweet clover, and common plantain. Black-tailed jackrabbits, Canada geese, and European starlings are the dominant animal species in this habitat.

Ruderal Upland Vegetation. This habitat is primarily associated with the upland zones surrounding the wetlands. The upland habitats are dominated by thistles, *Brassica* sp. (mustard, turnip), coyote bush, and plantain. Black-tailed jackrabbits, red-winged blackbirds, California ground squirrels, and Canada geese dominate the upland habitats surrounding the wetland areas.

Disturbed Areas. These habitats are characterized by degradation and human activity. The dominant plant species are tolerant of habitat disturbances and include grasses. Feral rabbits are the dominant animal species.

Beach. Small beach habitats occur in the vicinity of the Seaplane Lagoon and Breakwater Beach, and they may provide some foraging habitat for shorebirds.

Urban and Ornamental Landscapes. These maintained habitats dominate the industrial and residential portions of Alameda Point. Dominant vegetation includes introduced grasses, such as perennial ryegrass and Kentucky bluegrass, as well as ornamental trees such as flowering plum, olive, fir, and pine trees. Dominant animal species include American robins, European starlings, house sparrows, mourning doves, and feral cats.

Riprap. This habitat lines the shoreline of Alameda Point and forms the breakwater at the turning basin south of Alameda Point. Dominant plant species include fig-marigold, fescue, and ryegrass. Pelicans and double-crested cormorants use the breakwater areas for roosting. Western gulls use the breakwater and the riprap near the wetland habitats for nesting as well. Feral cats have been observed in the riprap near the wetland habitats.

2.4.4 Special Status Species

Special status species that occur or are expected to occur at Alameda Point are identified in several existing reports (U.S. Fish and Wildlife Service [USFWS] 1993) and are summarized below. The species listed below are federally or state-designated threatened or endangered species. Some species do not have legal status under federal or state endangered species acts but are identified by the state as "Species of Special Concern."

Plants. USFWS has identified the rare plants listed below as potentially occurring at Alameda Point (USFWS 1993).

- Contra Costa goldfields (*Lasthenia conjugens*)
- Santa Cruz tarplant (*Holocarpha macradenia*)
- Kellogg's horkelia (*Horkelia cuneata sericea*)

- Point Reyes bird's beak (*Cordylanthus maritimus palustris*)
- Adobe sanicle (*Sanicula maritima*)

Neither these plants nor other rare plants identified by the California Native Plant Society were found during vegetation surveys performed at Alameda Point in 1995 and 1997.

Fish. The four rare fish species listed below may occur in the open water areas adjacent to Alameda Point.

- Chinook salmon (*Oncorhynchus tshawytscha*), winter run
- Longfin smelt (*Spirinchus thaleichthys*)
- Delta smelt (*Hypomesus transpacificus*)
- Coho salmon (*Oncorhynchus kisutch*)

Reptiles. The Alameda whipsnake (*Masticophis lateralis euryxanthus*) is the only special status reptile species that may occur at Alameda Point.

Birds. Twenty-nine special status bird species that occur or may occur at Alameda Point are listed below along with associated sensitive habitats (such as breeding, nesting, and rookery sites), as applicable.

- California least tern (*Sterna antillarum browni*)
- American peregrine falcon (*Falco peregrinus anatum*)
- Western snowy plower (*Charadrius alexandrinus nivosus*), coastal population
- Salt marsh common yellowthroat (*Geothlypis trichas sinuosa*)
- Alameda song sparrow *(Melospiza melodia pusillula*)
- Double-crested cormorant (*Phalacrocorax auritus*), rookery sites
- California black rail (*Laterallus jamaicensis coturniculus*)
- California clapper rail (*Rallus longirostris obsoletus*)
- Caspian tern (*Sterna caspia*), nesting colonies
- Forster's tern (*Sterna forsteri*), nesting colonies
- California brown pelican (*Pelecanus occidentalis californicus*), nesting colony
- California horned lark (*Eremophila alpestris actia*)
- Loggerhead shrike (*Lanius ludovicianus*)
- California gull (*Larus californicus*)
- Northern harrier (*Circus cyaneus*), nesting sites
- Merlin (*Falco columbarius*)
- Long-billed curlew (*Numenius americuanus*), breeding sites
- Burrowing owl (*Athene cunicularia*), burrowing sites
- Common loon (*Gavia imer*), breeding sites
- Fork-tailed storm petrel (*Ocanodroma furcata*), rookery sites
- American white pelican (*Pelicanus erythrorhynchos*), nesting colony

- Clark's grebe (*Aechmophorus clarkii*)
- Western grebe (*Aechmophorus occidentalis*)
- Great blue heron (*Ardea herodias*), rookery sites
- Great egret (*Casmerodius albus*), rookery sites
- Snowy egret (*Egreta thula*), rookery sites
- Black-crowned night heron (*Nycticorax nycticorax*), rookery sites
- Black-shouldered kite (*Elanus caeruleus*), nesting colony
- Common murre (*Uria aalge*), nesting colony

Mammals. The seven special status mammals listed below have been identified as potentially occurring at Alameda Point.

- Salt marsh harvest mouse (*Reithrodonomys raviventris*)
- San Francisco dusky-footed woodrat (*Neotoma fuscipes annectens*)
- Townsend's western big-eared bat (*Plecotus townsendii townsendii*)
- California mastiff bat (*Eumops perotis californicus*)
- Northern (Steller) sea lion (*Eumetopias jubatus*)
- Salt marsh wandering shrew (*Sorex vagrens halicoetes*)
- Alameda Island mole (*Scapanus latimanus parvus*)

In 1995, a survey for the salt marsh harvest mouse was conducted in the West Beach Landfill Wetland and Runway Area Wetland. The survey was performed to identify potential receptors for evaluation in ERAs being conducted by the Navy for the IRP. No salt marsh harvest mice were captured during the survey.

2.5 FUTURE LAND USES

This section outlines the future land uses for Alameda Point. The discussion is based on the "NAS Alameda Community Reuse Plan" (EDAW 1996). The reuse plan identifies future land use categories and land use areas, which are summarized in this section and presented in Figure 2-18. The future land uses were employed to develop human health and ecological risk scenarios for the OU-2 IR sites. The following table summarizes the OU-2 IR sites, the associated land use areas, and categories as identified in the Alameda Point reuse plan. The table also lists human health exposure scenarios applicable for each site based on the future reuse. The exposure scenarios are described in more detail in Chapter 5.

Site No.	OU/Area	Land Use Area	Land Use Category	Human Exposure Scenarios
5, 10, 12	OU-2 Central Area	Civic Core	Mixed Use, R&D, Industrial, Open Space	Residential, Recreational, Occupational, CW
3	OU-2 Eastern Area	Civic Core	Mixed Use, R&D, Industrial, Open Space	Residential, Recreational, Occupational, CW
4	OU-2 Eastern Area	Inner Harbor	R&D, Industrial, Mixed Use, Park	Residential, Recreational, Occupational, CW
11, 21	OU-2 Eastern Area	Marina District	Commercial, Residential, Civic/institutional, Mixed Use	Residential, Recreational, Occupational, CW
9, 13, 19, 22, 23	OU-2 South Eastern Area	Inner Harbor	R&D, Industrial, Mixed Use, Park	Residential, Recreational, Occupational, CW
14	-	Northwest Territories	Light Industrial/R&D, Park	Recreational, Occupational, CW
25	-	Main Street Neighborhood	Residential, Civic/ Institutional, Park	Residential, Recreational, Occupational, CW

R&D – Research and Development; CW – Construction Worker

The following subsections provide descriptions on land use categories applicable to OU-2 sites as provided in the Alameda Point Reuse Plan referenced above.

Residential. The residential category includes single-family homes and two-family attached dwelling units.

Research and Development/Industrial Flex. The research and development/industrial flex category is intended for offices and research and development space locations; and supports manufacturing, warehousing, and distribution for the primary activities. Emphasis is placed on office and research uses with related manufacturing, warehousing, and distribution supporting the primary activities.

Civic/Institutional. The civic/institutional category includes schools; higher educational uses; and City of Alameda facilities that have a unique public character such as places of worship, private educational institutions, museums, and other cultural institutions.

Commercial. The commercial category includes (1) neighborhood commercial areas that meet convenience shopping needs, have restaurants, and have cafes and (2) community commercial areas that include retail stores, department stores, hotels, motels, conference and convention facilities, and offices.

Mixed Use. The mixed-use category involves development of two or more uses on a single site or within one structure. Specific models of the mixed-use category include (1) residential and office uses above or

adjacent to retail and other commercial uses and (2) retail and service commercial uses intermingled with research and development or light industry uses.

Parks. The parks category includes neighborhood parks, community parks, community open space, greenways, trails, regional parks, and other recreational facilities as defined in the reuse plan (EDAW 1996).

Open Space/Habitat. The open space/habitat category includes wetlands, wildlife habitats, and water-related habitats. Portions of the installation airfield area designated for use as a wildlife refuge (West Beach Landfill Wetlands and Runway Area Wetlands) are also included in this category.

2.6 BACKGROUND CHEMICAL CONCENTRATION DETERMINATION

Background concentrations of naturally occurring chemicals in the environment at Alameda Point were compared with analytical results for samples collected from IR sites to identify site chemicals potentially resulting from historical site activities. Determination of background conditions was an integral part of the baseline HHRA and ERA.

According to EPA (1989a), background chemicals at Alameda Point can be categorized as follows:

- Nonanthropogenic or naturally occurring: minerals or other substances present in the environment in forms that have not been influenced by human activities
- Anthropogenic: natural and manmade substances present in the environment as a result of human activities not related to Navy activities

Nonanthropogenic chemicals are naturally occurring organic or inorganic chemicals that are present in soil or groundwater as part of the geological or hydrogeological conditions of the area and are in an unaltered form not related to human activity (for example, metals from rock formations or polycyclic aromatic hydrocarbons [PAH] from forest fires). Anthropogenic background chemicals are related to human activity in the region but are unrelated to Navy operations. Metals and PAHs at Alameda Point may be considered anthropogenic background chemicals because of potential sources such as the fill material, car exhaust, and the marsh crust.

The history of Alameda Point's construction indicates that almost the entire installation is located on marshland, tidal flats, and bay margin (submerged land) that has been filled with sediment dredged from the Oakland Inner Harbor, San Francisco Bay, and the ship channel and Seaplane Lagoon area. The species and concentrations of metals and PAHs present in the fill sediment are not known, but they may have been impacted by industrial activities along the original Oakland bayshore and Alameda Island before the dredged material was placed.

The following subsections focus on chemical concentrations in soils and groundwater considered to be representative of site-specific background conditions at Alameda Point. The soil and groundwater background conditions were determined using a series of statistical tests conducted on site-specific background data selected for each medium at Alameda Point. The statistical evaluation methodology for soils is described in a background determination work plan (PRC 1997c), while the methodology and results for groundwater are described in a technical memorandum for estimation of ambient metal concentrations in shallow groundwater (TtEMI 1998b). Section 2.6.1 provides a summary of a detailed description of the determination of site-specific background conditions in soil at Alameda Point provided in two letter reports in Appendix B. Section 2.6.2 provides a summary of a detailed description of the determination of site-specific background conditions in groundwater at Alameda Point provided in the aforementioned technical memorandum (TtEMI 1998b).

2.6.1 Soil Background Determination Methodology

Site-specific soil background concentrations at Alameda Point were determined for inorganic chemicals and PAHs. Inorganic chemicals present in natural soil compositions are considered nonanthropogenic. Concentrations of inorganic chemicals also may be affected by non-site-related anthropogenic activities. Random detections of PAHs in samples collected from the fill material in many areas of Alameda Point are considered to be anthropogenic for the following two reasons:

- RWQCB lists a total ambient level of PAHs in San Francisco Bay sediment of 5.13 milligrams per kilogram (mg/kg) (RWQCB 1996). Because Alameda Point was constructed using bay sediment, PAHs detected at or below this concentration are likely to represent ambient bay levels.

- Because of the installation's urban location, soil at Alameda Point is expected to contain ambient levels of PAHs. The Agency for Toxic Substances and Disease Registry (ATSDR) has published general background PAH concentrations for urban soils as high

as 62 and 166 mg/kg for heavy and light molecular weight PAHs, respectively (ATSDR 1995).

2.6.1.1 Site-Specific Background Inorganic Chemical Concentration Determination

The methodology used in developing the site-specific soil background data for Alameda Point consisted of three steps that are discussed briefly. Appendix B provides greater detail on the site-specific background data selection process. The three steps were as follows:

- Division of the installation into areas with geologically similar soils that could be represented by a single site-specific background data set
- Review of the RI database for selection of appropriate site-specific background samples
- Statistical analyses of data sets for each area to determine site-specific background concentrations

Division of the Installation into Geologically Similar Areas. Alameda Point was constructed using fill material dredged from San Francisco Bay over a period of 75 years (1900 to 1975). Because the fill material was dredged from various locations in the bay, there is substantial variation in the lithology of the fill material across the installation. As discussed in Section 2.2, the thickness of the fill material varies across the installation. Five discrete fill areas were initially identified for determining the variability in the fill material encountered across the installation. The five areas were the far western portion of the installation (the "IR Site 1/IR Site 2" area), a small strip of land bordering the Oakland Inner Harbor, the runway area from east of the runway to the installation boundary, and two areas within the southeastern corner of the installation. Iron and manganese data were statistically compared to determine whether these areas contained geologically similar soils and could be represented by one site-specific background data set. Results of the statistical comparison indicated that some areas could be combined but that more than one data set would be needed to represent site-specific background concentrations for the entire installation. Therefore, the five initially identified areas were reduced to three representative background areas. Specifically, the yellow, pink, and blue areas shown in Figure 2-19 were designated as representative background areas for Alameda Point. The parts of the installation included in each of the three site-specific background areas are listed below.

- Yellow area: far western portion of the installation (Fill Area 3)
- Pink area: runway area and central portion of the installation (Fill Area 1)
- Blue area: southeastern portion of the installation (Fill Area 2)

Review of the RI Database for Appropriate Soil Background Samples. Soil samples collected as part of the IRP investigation were reviewed on a sample-by-sample basis to select samples that could represent site-specific background concentrations. The data review was conducted in accordance with regulatory guidance (DTSC 1994).

Selection of the site-specific background data for each of the three background areas listed above consisted of the following steps:

- All samples collected from IR sites that could contain metal contamination based on site history were excluded as background samples.
- Samples collected from soil borings that contained non-PAH organic chemicals, except for insignificant levels of laboratory contaminants and organic carbon, were excluded as background samples.
- Samples collected from IR sites were excluded as background samples.

Samples that passed these three screening steps were considered to be potential background samples. For the three areas identified above, 247 samples were selected from the RI database as potential background samples. Appendix B provides a list of the sample identification numbers and depth intervals for all the samples selected. A total of 51, 56, and 140 samples were identified as potential background samples for the yellow, pink, and blue areas, respectively.

Determination of Soil Background Levels. Data sets established for the three background areas were statistically evaluated using a methodology described in the "Final Statistical Methodology for Background Comparisons" report (PRC 1997c). Tables 2-2a through 2-2c present statistical summary results that define the site-specific inorganic chemical background data for the three background areas at Alameda Point. The site-specific background data were used in identifying chemicals of concern (COC) for IR sites at Alameda Point. COC selection procedures are presented in Chapter 5 of this report.

2.6.1.2 Ambient PAH Concentration Determination

Two gas plants and an oil refinery were located near the future locations of the Alameda Facility/Alameda Annex and Alameda Point from the late 1800s until the 1920s. These facilities are believed to have discharged petroleum waste to adjacent marshlands. The waste migrated over much of the surface of the surrounding marshlands and was deposited on the marsh surface through tidal actions, leaving a layer of

contaminated sediment under what would later become the Alameda Facility/Alameda Annex and the eastern portion of Alameda. This layer is referred to as the marsh crust. Further west, at Alameda Point, the waste was deposited on tidal flats now known as the former subtidal area. Fill material dredged from the Oakland Inner Harbor and surrounding San Francisco Bay was placed on these areas from as early as 1887 to as late as 1975, encapsulating the former subtidal area and marsh crust under the fill.

The fill material was placed prior to any Navy activities that could have released PAHs to the environment. Therefore, ambient PAH concentrations in soil are not attributable to historical Navy activities at Alameda Point. The methodology used to develop the Alameda Point ambient PAH data set and the data set itself will be described in a technical memorandum to be prepared following the completion of the ambient PAH concentration determination.

As discussed in Appendix P, the following four PAHs are the most significant risk-contributing PAHs at Alameda Point:

- Benzo(a)pyrene
- Benzo(a)anthracene
- Benzo(b)fluoranthene
- Indeno(1,2,3-c,d)pyrene

To expedite development of the RI and FS reports, the Navy focused on these four PAHs for the development of the ambient PAH data set. Refer to Appendix P for additional details.

Although insufficient data were available for development of Alameda Point ambient concentrations for dibenzo(a,h)anthracene, dibenzo(a,h)anthracene concentrations reported for sediment samples collected from various locations in San Francisco Bay were available for comparison with site concentrations. Bay sediment concentrations for various chemicals are reported under the Bay Protection and Toxic Cleanup Program (BPTCP) by the California State Water Resources Control Board (SWRCB) and California Department of Fish and Game at SWRCB's web site: http://www.swrcb.ca.gov/bptcp/ (File Name: Chem3846.dbf). Dibenzo(a,h)anthracene concentrations reported for San Francisco Bay sediment were compared to site-specific concentration ranges for dibenzo(a,h)anthracene. If the comparison shows that site-specific dibenzo(a,h)anthracene concentrations are within the range of bay sediment dibenzo(a,h)anthracene concentrations, the dibenzo(a,h)anthracene concentrations detected at the site are not be considered site-related.

The ambient PAH data set was used to determine human health risks posed by ambient PAH concentrations in soils at Alameda Point. Carcinogenic human health risks and noncarcinogenic hazard indices (HI) for the ambient PAH data set were calculated using both Navy and DTSC risk assessment assumptions. Chapter 5 and Appendix D describe the differences in the Navy and DTSC risk assessment assumptions. During the human health risk evaluation for each IR site, human health risks from PAH concentrations detected at the site were compared to the human health risks posed by the ambient PAH concentrations at Alameda Point. The comparison was used to determine whether a remedial action for addressing PAH concentrations was necessary at the site. Risks contributed by ambient concentrations of PAHs were subtracted from the total site risk prior to the determination of the need for a remedial action at the site.

2.6.2 Groundwater Background Determination Methodology

Metals occur naturally in groundwater at concentrations that vary among locations. Some concentrations of metals in groundwater at Alameda Point may not be naturally occurring but are unrelated to Navy activities at the installation.

During technical meetings between the Navy and regulatory agencies held on April 28 and 29, 1998, the BCT decided to follow a statistical approach for determination of the concentrations of ambient metals in groundwater similar to that used to determine the concentrations of ambient metals in soils at Alameda Point (PRC 1997c). This simplified approach was followed because of the transitory nature of groundwater and the following factors arising from the construction of Alameda Point:

- The presence of anthropogenic metals in fill sediment
- The slow leaching of both naturally occurring and anthropogenic metals from the marine sediment into the groundwater
- The marine-derived fill sediment being placed in a column of seawater and serving as the aquifer material
- The disequilibrium of groundwater chemistry because of the slow flushing of saline connate water from the pore spaces and the large geochemical gradients that occur within small horizontal and vertical distances
- Existing and potential future seawater intrusion induced by remediation- or supply-based pumping

In consultation with the BCT, the Navy proposed estimating the concentration limits of ambient metals in the following manner:

- Select well locations that appear to be unaffected by IR site-related contamination to create an initial data set to be used to determine ambient concentrations of metals
- Compare all organic groundwater data from the initial data set to the 1996 tap water preliminary remediation goals (PRG) to exclude impacted wells
- Examine the initial data set using probability plots and Rosner's test to exclude outlier concentrations of metals
- Test the remaining data (without outliers) for normality using a statistical graphics program
- Prepare summary statistics and estimate the ambient concentrations of metals using the tested data set

A subsequent meeting between the regulatory agencies and the Navy was held on May 11, 1998, to identify monitoring wells at Alameda Point for potential use in developing site-specific background groundwater concentrations. Figure 2-20 shows the locations of the 35 unaffected (background) wells selected during the meeting for Alameda Point.

The data set used to determine the concentrations of ambient metals in groundwater was limited to data for groundwater samples collected from the FWBZ. Data for groundwater samples collected from the SWBZ were not included in the data set because of extensive saltwater intrusion and the inherent inability of analytical methods to detect trace metals in the presence of very high levels of marine salts. A detailed description of the process used to develop the ambient metal data set and the statistical procedure used to estimate the concentrations of ambient metals in groundwater at Alameda Point is provided in Appendix B.

Table 2-3 summarizes the results of the statistical procedure, providing estimated ambient metal concentrations at both the 80th percent lower confidence limit (LCL) of the 95th percentile of the distribution (80 LCL/95) and at the 95th percent upper confidence limit (95 UCL) for shallow groundwater (FWBZ) at Alameda Point, statistical features of the data set, and relevant water quality information. The estimated concentrations of ambient metals in groundwater at the 80 LCL/95 in many cases exceeded the maximum contaminant levels (MCL) for a municipal water supply (RWQCB 1995). Specifically, the estimated concentrations of antimony, cadmium, iron, manganese, and thallium exceeded

their respective MCLs. The site-specific background data were used in developing COCs for IR sites at Alameda Point. COC selection procedures and results are presented in Chapter 5 of this report.

2.7 INSTALLATION-WIDE ENVIRONMENTAL INVESTIGATIONS

This section briefly describes the environmental investigations performed at Alameda Point. Table 1-1 provides a historical summary of investigations conducted at Alameda Point prior to and under the IRP. The following subsections provide an overview of investigation activities conducted across all sites covered by the Alameda Point IRP.

2.7.1 Investigations Conducted Prior to the Initiation of the Installation Restoration Program

In 1979, a fuel contamination study was conducted by the Navy to investigate the extent of the subsurface fuel contamination in the vicinity of IR Site 3 (Kennedy Engineers 1980). The Navy began environmental site investigations at Alameda Point under the NACIP program in 1982. Under the NACIP program, an IAS was conducted to assess the entire installation for potential areas where contaminants may have affected soils and/or groundwater (E&E 1983). A verification step/characterization study was then performed in 1985 at sites identified for further study in the IAS (Wahler Associates 1985).

2.7.2 Investigations Conducted Under the Installation Restoration Program

The Navy undertook the RI/FS at the initial 23 IR sites using a phased approach. Table 1-1 lists the various environmental investigation phases performed under the RI/FS program and the sites investigated under each phase. Investigations for Phases 1, 2A, 2B, and 3 were conducted initially to evaluate the potential impact of site operations on soil and groundwater. Investigation results were summarized in two different reports referred to as the Phase 1 and 2A report (PRC and James M. Montgomery [JMM] 1993a) and the Phase 2B and 3 report (PRC and JMM 1992a).

During 1994 and 1995, two follow-on investigations were conducted to collect data to fill the gaps from the Phase 1 and 2A, and Phase 2B and 3 investigations; these follow-on investigations are referred to in this report as the Contract Task Order (CTO) No. 260 Follow-on Investigation (PRC and MW 1996a) and the CTO No. 280 Follow-on Investigation (PRC and MW 1996b), respectively. The CTO No. 260

Follow-on Investigation was conducted at IR Sites 4, 5, 8, 10, 12, and 14. The CTO No. 280 Follow-on Investigation was conducted at IR Sites 1, 2, 3, 6, 7, 9, 11, 13, 15, 16, 19, 21, 22, and 23.

The Phase 4 investigation (ecological assessment) was conducted in 1993 and 1994 and in 1996 and 1997 at IR Sites 17, 20, and 24. The ecological assessment was conducted to determine whether any of the IR sites provide necessary habitats for special status species defined in Chapter 2, to identify benthic communities inhabiting the sediments at the sites, and to investigate the potential for adverse effects on ecological receptors resulting from exposure to site-related chemicals. The 1996 and 1997 investigation focused on delineating the extent of contamination identified at the sites during the 1993 and 1994 investigation.

In 1992 and 1993, the Phase 5 and 6 Solid Waste Water Quality Assessment Test (SWAT) investigation was performed at IR Sites 1 and 2 (PRC 1993). This investigation was conducted to evaluate whether the groundwater at IR sites 1 and 2 was impacted by chemicals potentially disposed of at the 1943-1956 disposal area (IR Site 1) and West Beach Landfill (IR Site 2). The IR sites and the associated buildings are shown in Figure 1-3.

2.7.3 Environmental Baseline Survey

After Alameda Point was designated for closure in September 1993, ongoing environmental restoration and compliance programs were coordinated for conveyance of properties and for accelerated property conversion and reuse activities. As mandated under the Base Closure and Realignment Act of 1988 and the Defense Base Closure and Realignment Act of 1990, collectively known as BRAC, an EBS was performed to identify the environmental condition of all property affected by base closure. As part of the EBS, all Alameda Point on-shore property was divided into 208 parcels grouped into 23 zones based on geographic location and expected land use. Site-specific information gathered during the EBS was used to determine each parcel's suitability for leasing or transfer based on its intended use and the Defense Authorization Act of 1997 (enacted in September 1996).

2.7.4 Storm Sewer Repair Program (Installation Restoration Site 18)

A study of the storm sewer system at Alameda Point is being conducted to support the IRP in determining the impact of contaminated groundwater originating from IR sites that is infiltrating into the storm sewer system and to recommend potential repairs to the system for the affected lines. The storm sewer system

consists of the storm sewer lines, manholes, catch basins, and outfalls on the installation as well as in the outlying installation housing area (see Figure 2-21). The storm sewer system consists of about 194,000 linear feet of storm sewer lines that empty into the Seaplane Lagoon, the Oakland Inner Harbor, and San Francisco Bay at 46 outfall locations. From 1943 to 1975, wastewater was discharged to the storm sewer system from surface runoff areas and industrial processes in the buildings serviced by the system. Currently the system receives only normal storm water runoff from rainfall and irrigation activities.

In support of the Alameda Point storm sewer repair program, a qualitative evaluation of the storm sewer system was performed to determine whether the system has been affected by contaminated groundwater infiltration. The results of the storm sewer repair program will be summarized in the draft OU-4 RI report (IR Site 18), which will document the background information evaluated for the storm sewer repair program, summarize the findings of the study, evaluate potential corrective actions for storm sewer repairs, and present conclusions and recommendations. Previous investigations of or associated with the Alameda Point storm sewer system are summarized in the "Draft Storm Sewer Repair Project Report" (TtEMI 1999a).

In July 1997, a time-critical removal action was completed to remove contaminated sediments from storm sewer manhole inverts, catch basins, and accessible lines at Alameda Point. During the removal action, significant water infiltration was discovered in many of the lines, which were found to be cracked, offset, separated, or in otherwise poor condition. Also, the 1997 storm water annual report (Radian International LLC [Radian] 1997) summarizes dry weather storm water sampling performed under the storm water pollution prevention plan that indicated possible infiltration of contaminated groundwater into the system. About 40,000 linear feet of the storm sewer system is estimated to be influenced by contaminated groundwater plumes throughout Alameda Point, mainly on and around the IR sites.

Engineering controls and remedial actions for removal of contaminated surface soils are being instituted at Alameda Point to minimize current contaminant sources and thus improve the quality of storm water runoff. Storm water runoff is being monitored under Alameda Point's current storm water management plan (Radian 1996).

2.7.5 Fuel Line and UST Removal and Abandonment

An installation-wide underground fuel line and underground storage tank (UST) removal and abandonment project was conducted at Alameda Point between June 1998 and January 1999. The

underground fuel lines were used for distribution of jet fuel, gasoline, and diesel fuels. Approximately 34,000 linear feet of inactive pipeline were removed and 23,000 linear feet of pipeline were abandoned in place. The underground fuel lines generally consisted of 1.5- to 8-inch-diameter steel lines found at depths ranging from 1 to 5 feet bgs. Fuel lines associated with OU-2 IR Sites 3, 5, 11, 13, 19, 21, and 22 were removed, as shown in Figure 2-22. Analytical results for soil and groundwater samples collected during the fuel line removal and abandonment efforts at Alameda Point will be presented in the draft final OU-2 RI report.

During the removal and abandonment project, 26 USTs were removed and 1 UST was closed in place at Alameda Point. Of the 26 excavated USTs, 19 were located near OU-2 IR sites as described below.

- A 1,000-gallon tank (UST 372-2) used for storage of lubricating oil was removed from Building 327 located near the East Gate entrance on 9th Street south of Atlantic Avenue at the southwestern corner of IR Site 4.
- Sixteen tanks (USTs 37-1 through 37-8 and USTs 37-13 through 37-20) used for storage of diesel fuel, gasoline, jet fuel, waste oil, aircraft oil, solvents, and combustible liquid wastes were removed from Area 37 located just south of IR Sites 21 and 11. Tanks 37-1 through 37-8 and 37-13 through 37-16 were 25,000-gallon tanks; Tanks 37-17, 37-18, and 37-19 were 13,000-gallon tanks; and Tank 37-20 was a 1,500-gallon tank.
- A 2,000-gallon diesel fuel UST that provided fuel to an emergency diesel electrical generator was removed from the southwestern corner of Building 62 just east of IR Site 5.
- A former waste oil and solvent UST (T-5-3) with a capacity of 1,000 gallons or less was removed from IR Site 5.

Analytical results for soil and groundwater samples collected during the UST removal efforts at Alameda Point will be presented in the draft final OU-2 RI report.

In conjunction with the removal and abandonment project, a Site Characterization Analysis Penetrometer System (SCAPS) investigation was implemented along certain portions of the underground fuel lines from May 7 through July 3, 1998 (TtEMI 1999b). SCAPS is a screening tool for rapid in situ examination of soil and groundwater and can be used to reduce the overall cost of site characterization. SCAPS uses direct-push technology (as opposed to drilling technology) to deploy tools for site characterization. These tools include a combined laser-induced fluorescence (LIF) and cone penetrometer (CP) probe used to detect impacts on subsurface soils by petroleum, oil, and lubricant (POL) compounds and to provide geotechnical soil classification. SCAPS technology was used to support fuel line removal

and abandonment at Alameda Point by providing preliminary data on possible soil and groundwater contamination along the pipelines. Soil samples collected at selected SCAPS locations were analyzed by a laboratory, and the laboratory data were compared to SCAPS LIF data. Soil samples were analyzed for benzene, toluene, ethylbenzene, and xylene (collectively known as BTEX); TPH (gasoline range); TPH (diesel range); and TPH (motor oil range). The SCAPS data showed that fluorescence intensity counts of (1) less than 10,000 suggested an absence of TPH contamination and (2) greater than 20,000 suggested possible high levels of TPH contamination (TtEMI 1999b). The comparison of SCAPS data with laboratory analytical results for soil samples did not indicate a correlation between LIF data and laboratory measurements of TPH in soil. A more detailed description of the SCAPS methodology, sampling locations, and results is presented in the "Summary Report Oversight of Site Characterization Analysis Penetrometer System to Support Fuel Line Removal and In-Place Closure, Alameda Point" (TtEMI 1999b).

2.7.6 Radiological Surveys and Removal Actions

During Navy operations at Alameda Point from the 1940s through early 1960, radioluminescent aircraft instrument dials were refurbished with radium 226. This operation was conducted at IR Sites 5 and 10. Radium paint was washed down sink drains that led to the storm sewer system. Radiological surveys were conducted at IR Sites 5 and 10 to identify areas with radioactive contamination. Removal actions are underway to remove affected storm sewer lines and other impacted areas. A final report will be submitted to the Navy when all of these removal actions are complete.

2.7.7 Treatability Studies

Results of treatability testing activities at specific IR sites are summarized in Chapters 6 through 10.

TABLE 2-1
SUMMARY OF GROUNDWATER HYDRAULIC PARAMETERS
ALAMEDA POINT

Hydrostratigraphic Unit	Hydraulic Parameter	East Bay Margin	Western Region	Central Region	Southeastern Region
First Water-Bearing Zone (Artificial Fill/ Merritt Sand)	Hydraulic Conductivity	9.8 X 10^{-3} ft/min	$1.1x10^{-2}$ to $4.1x10^{-2}$ ft/min	$6.3x10^{-3}$ to $1.5x10^{-2}$ ft/min	$1.9x10^{-3}$ to $5.9x10^{-3}$ ft/min
	Storage Coefficient	NA	0.0013 to 0.012	0.005 to 0.01	0.0004 to 0.0012
	Specific Yield	NA	0.005 to 0.23	0.046 to 0.23	0.035 to 0.22
		(Values from aquifer pump tests)	(Values from aquifer pump tests)	(Values from aquifer pump tests)	(Values from aquifer pump tests)
Confining Layer (Bay Sediments)	Hydraulic Conductivity	NA	$7.1x10^{-5}$ ft/min (Values from slug testing)	9.65 x 10^{-6} ft/min (Values from slug testing)	No confining layer present
Second Water-Bearing Zone (Merritt Sand/ Upper San Antonio Formation)	Hydraulic Conductivity	$7.5x10^{-4}$ ft/min	$1.2x10^{-3}$ to $3.7x10^{-3}$ ft/min (Values from slug testing)	NA	No SWBZ present, FWBZ extends to the Yerba Buena Mud
	Aquifer Pumping Test Observations	NA	No drawdown observed in response to pumping in FWBZ.	No drawdown observed in response to pumping in FWBZ.	No confining layer is present to preclude hydraulic communication.
Regional Aquitard (Yerba Buena Mud)	Hydraulic Conductivity	$2.8x10^{-7}$ to $1.4x10^{-6}$ ft/min	NA	NA	NA
Deep Aquifer System (Alameda Formation)	Hydraulic Conductivity	$2.1x10^{-2}$ to $3.9x10^{-2}$ ft/min	$2.5x10^{-2}$ ft/min	NA	NA
	Aquifer Pumping Test Observations	No drawdown observed in overlying formation.	No observation wells available for monitoring. Pumping curves did not indicate leakage from other formations.	NA	NA

Notes:
ft/min = Feet per minute
FWBZ = First water-bearing zone
NA = Not available
SWBZ = Second water-bearing zone

TABLE 2-2a
BACKGROUND SOIL DATA SUMMARY
YELLOW AREA
OU-2, ALAMEDA POINT
(Page 1 of 2)

Chemical	SQL Range	Frequency of Detection [a]	Minimum Detected Concentration	Maximum Detected Concentration	Mean Concentration	95 UCL Concentration	80 LCL/95 Concentration
Inorganic Compounds (mg/kg)							
Aluminum [b]	NA	50/50	20	13,300	6,119	6,841	11,091
Antimony [e]	2.5-7.3	3/50	2.8	3.6	3.0	3.1	4.2
Arsenic [b]	10-12	21/50	1.1	33	7.7	9.5	20.3
Barium [c]	21-24	43/50	19.8	260	30.0	43.0	99.4
Beryllium [b]	1-1.2	9/50	0.3	1.3	0.57	0.63	0.95
Cadmium [b]	0.36-1.2	11/50	0.33	2.9	0.66	0.80	1.6
Calcium [c]	NA	50/50	500	97,000	3,411	5,256	12,995
Chromium [d]	NA	50/50	5.0	69.7	32.0	34.4	48.5
Cobalt [b]	5-6	20/50	4.3	11.4	4.3	5.0	2.6
Copper [b]	5.5-5.6	48/50	4.2	49	15.7	19.1	39.3
Iron [b]	NA	50/50	10	20,800	10,247	11,410	17,791
Lead [c]	NA	50/50	3.3	180	20.7	41.2	118
Magnesium [c]	NA	50/50	500	8,820	2,540	3,192	6,231
Manganese [b]	NA	50/50	5.0	330	136.2	157.3	281
Mercury [b]	0.05-0.11	5/9	0.05	0.18	0.08	0.12	0.15
Nickel [d]	NA	50/50	5.0	71.1	27.7	30.5	46.7
Potassium [b]	NA	50/50	500	1,700	914	996	1,479
Silver [d]	0.48-6	6/50	0.52	30	2.9	4.1	11.0
Sodium [b]	500-610	11/50	232	1,380	358	432	867
Titanium [b]	NA	41/41	280	663	456	480.2	603
Vanadium [b]	NA	50/50	15.6	50.0	25.5	27.7	40.9
Zinc [b]	NA	50/50	17.0	140.0	46.9	55.8	108.6

TABLE 2-2a
BACKGROUND SOIL DATA SUMMARY
YELLOW AREA
OU-2, ALAMEDA POINT
(Page 2 of 2)

Notes:

(a) Frequency of detection values are expressed as follows: number of samples in which chemical was detected/total number of samples for which chemical was analyzed.
(b) Data log normally distributed
(c) Data not normally or log normally distributed; calculated 80 LCL/95 for natural logarithm-transformed data
(d) Data not normally or log normally distributed; calculated 80 LCL/95 from arithmetic mean and standard deviation
(e) Too few detections to determine distribution; calculated 80 LCL/95 from arithmetic mean and standard deviation

µg/kg	Microgram per kilogram
mg/kg	Milligram per kilogram
80 LCL/95th Percentile	80 percent lower confidence limit of the 95th percentile of the distribution
95 UCL	95 percent upper confidence limit of the mean concentration
NA	Not applicable
SQL	Sample quantitation limit

TABLE 2-2b
BACKGROUND SOIL DATA SUMMARY
PINK AREA
OU-2, ALAMEDA POINT
(Page 1 of 2)

Chemical	SQL Range	Frequency of Detection [a]	Minimum Detected Concentration	Maximum Detected Concentration	Mean Concentration	95 UCL Concentration	80 LCL/95 Concentration
Inorganic Compounds (mg/kg)							
Aluminum [b]	NA	55/55	1,760	22,600	5,231	6,528	12,930
Antimony [c]	0.46-11.0	18/55	0.7	8.6	2.2	2.7	5.7
Arsenic [b]	0.59-10	45/55	0.44	15.6	1.8	3.1	8.7
Barium [b]	NA	55/55	6.9	156	36.0	47.4	103
Beryllium [c]	0.15-1.0	28/55	0.25	1.47	0.50	0.60	1.2
Cadmium [b]	0.08-1.0	11/55	0.1	3.2	0.19	0.42	1.33
Calcium [b]	NA	55/55	816	66,600	2,913	4,686	12,513
Chromium [c]	NA	55/55	15.6	66.7	30.4	33.1	50.0
Cobalt [d]	3.96-5.7	48/55	3.0	49.7	6.1	7.9	19.3
Copper [b]	8.8-10.2	52/55	3.1	49.1	7.5	10.5	24.3
Iron [b]	NA	55/55	4,500	27,900	9,365	11,230	20,394
Lead [b]	1.9-3.0	51/55	0.47	165	4.1	9.9	32.6
Magnesium [b]	NA	55/55	1,290	8,800	2,627	3,172	5,969
Manganese [b]	NA	55/55	55.5	748	126.1	167.6	363.1
Mercury [b]	0.06-0.27	7/54	0.057	2.71	0.063	0.12	0.34

TABLE 2-2b
BACKGROUND SOIL DATA SUMMARY
PINK AREA
OU-2, ALAMEDA POINT
(Page 2 of 2)

Chemical	SQL Range	Frequency of Detection [a]	Minimum Detected Concentration	Maximum Detected Concentration	Mean Concentration	95 UCL Concentration	80 LCL/95 Concentration
Inorganic Compounds (mg/kg)							
Nickel [b]	NA	55/55	11.5	80.4	25.8	30.1	49.7
Potassium [b]	NA	55/55	209	2,480	683	819	1,523
Silver [b]	0.18-1.47	11/55	0.32	5.6	0.30	0.58	1.73
Sodium [b]	NA	55/55	62.6	1,580	335.9	503.4	1,251
Titanium [e]	NA	1/1	518	518	518	NA	NA
Vanadium [c]	NA	55/55	10.5	55.3	22.6	25.1	44.6
Zinc [b]	18	54/55	10	191	22.6	29.2	61.5

Notes:

(a) Frequency of detection values are expressed as follows: number of samples in which chemical was detected/total number of samples for which chemical was analyzed.
(b) Data lognormally distributed; calculated 80 LCL/95 for natural logarithm-transformed data
(c) Data normally distributed
(d) Data not normally or lognormally distributed; calculated 80 LCL/95 from arithmetic mean and standard deviation
(e) Too few detections to determine distribution; calculated 80 LCL/95 from arithmetic mean and standard deviation

µg/kg	Microgram per kilogram
mg/kg	Milligram per kilogram
80 LCL/95	80 percent lower confidence limit of the 95th percentile of the distribution
95 UCL	95 percent upper confidence limit of the mean concentration
NA	Not applicable
SQL	Sample quantitation limit

TABLE 2-2c
BACKGROUND SOIL DATA SUMMARY
BLUE AREA
OU-2, ALAMEDA POINT
(Page 1 of 2)

Chemical	SQL Range	Frequency of Detection [a]	Minimum Detected Concentration	Maximum Detected Concentration	Mean Concentration	95 UCL Concentration	80 LCL/95 Concentration
Inorganic Compounds (mg/kg)							
Aluminum [b]	NA	88/88	2,880	26,800	5,703	7,078	15,509
Antimony [e]	0.46-9.2	2/88	0.89	1.0	1.8	2.0	4.4
Arsenic [b]	0.61-13	33/88	0.74	23.0	2.2	4.8	19.2
Barium [c]	24-25	85/88	0.30	198	48.6	55.5	114.9
Beryllium [c]	0.2-1.3	25/88	0.09	0.77	0.32	0.36	0.76
Cadmium [c]	0.06-1.3	29/88	0.1	0.82	0.31	0.36	0.78
Calcium [b]	NA	88/88	1,360	19,200	3,033	4,181	10,958
Chromium [c]	NA	88/88	11.4	81.7	33.6	36.4	60.1
Cobalt [c]	3.9-6.8	66/89	1.9	14	5.0	5.6	10.6
Copper [b]	5.8-6.3	83/89	4.2	89.4	10.4	15.1	42.7
Iron [c]	NA	88/88	760	26,900	10,013	11,087	20,390
Lead [b]	1.4-6.8	27/88	1.3	41	3.2	5.2	16.1
Magnesium [b]	NA	88/88	1,510	42,400	2,557	3,159	6,858
Manganese [b]	NA	88/88	50	1,060	126	160	365
Nickel [b]	NA	88/88	11.6	88.5	26.9	31.9	63.4
Potassium [b]	610	87/88	310	6,382	800	997	2,203
Selenium [c]	0.42-13	1/88	5.7	5.7	2.9	3.3	7.1
Silver [e]	0.18-6.5	2/88	0.44	0.61	0.95	1.2	3.4
Sodium [b]	288-650	68/88	88.1	3,510	299.8	473.1	1,473
Thallium [c]	0.36-13	1/88	5.3	5.3	2.4	2.8	6.9
Titanium [c]	NA	66/66	223	1,020	408.4	444.3	706.7
Vanadium [c]	NA	88/88	12.8	62.3	22.4	24.2	40.5
Zinc [b]	NA	88/88	14	84	26.2	31	61.0

TABLE 2-2c
BACKGROUND SOIL DATA SUMMARY
BLUE AREA
OU-2, ALAMEDA POINT
(Page 2 of 2)

Notes:

(a) Frequency of detection values are expressed as follows: number of samples in which chemical was detected/total number of samples for which chemical was analyzed.
(b) Data lognormally distributed; calculated 80 LCL/95 for natural logarithm-transformed data
(c) Data normally distributed
(d) Data not normally or lognormally distributed; calculated 80 LCL/95 from arithmetic mean and standard deviation
(e) Too few detections to determine distribution; calculated 80 LCL/95 from arithmetic mean and standard deviation

mg/kg	Milligram per kilogram
µg/kg	Microgram per kilogram
80 LCL/95	80 percent lower confidence limit of the 95th percentile of the distribution
95 UCL	95 percent upper confidence limit of the mean concentration
NA	Not applicable
SQL	Sample quantitation limit

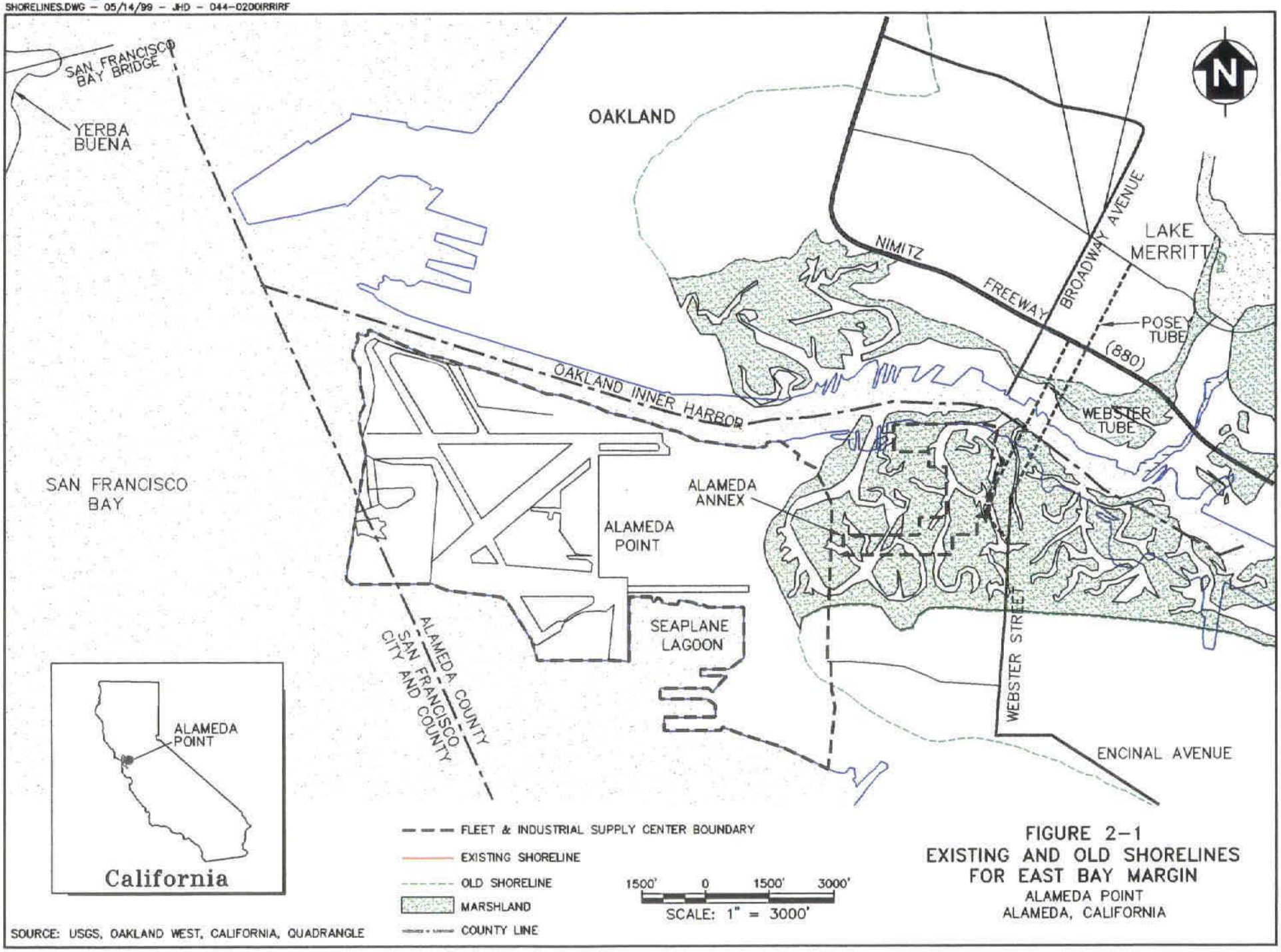
TABLE 2-3
AMBIENT CONCENTRATIONS OF METALS IN SHALLOW GROUNDWATER
OU-2, ALAMEDA POINT

Chemical [a]	Reported Detection Limit (µg/L)	Frequency [b] of Detection	Minimum Detected Concentration (µg/L)	Maximum Detected Concentration (µg/L)	Mean Concentration (µg/L)	95 UCL Concentration (µg/L)	80 LCL/95th Concentration (µg/L)	MCL[c]
Aluminum	8.4-223	51/176	3	3,970	32.12	96.2	439.13	1,000
Antimony	2-37.5	12/176	2.5	47.8	5.83	11.8	45.77	6
Arsenic	1.9-100	94/179	2	40.7	4.54	8	28.39	50
Barium	4.3-55.4	144/176	2.3	1,260	34.06	123.3	574.73	1,000
Beryllium	0.1-3.7	18/176	0.94	3	0.49	1	3.83	4
Cadmium	0.2-8.0	16/176	0.32	6.5	0.53	1.3	5.38	5
Calcium	898-1370	176/180	620	513,000	17,865	78,223	379,269	NA
Chromium	0.6-32	23/176	0.74	82.8	1.54	3.4	13.79	50
Chromium (hexavalent)-n	10.0	1/3	4	4	34.7	100.6	NA	NA
Cobalt	2.3-17.2	6/176	2.5	10.5	3.5	4.6	11.57	NA
Copper	0.4-69.7	54/176	2.1	27.3	3.97	7.5	27.48	1,000
Iron	4.8-363	119/180	7.2	24,400	108.58	1,624	7135	300
Lead	0.8-20	18/180	1.2	28.4	0.91	1.3	3.88	NA
Magnesium	NA	180/180	549	1,070,000	15,092	103,358	500,168	NA
Manganese	1.1-12.3	172/180	1.1	2,480	86.01	1,171	5213	50
Mercury-n	0.1-0.29	3/180	0.2	0.3	0.1	0.1	0.15	2
Molybdenum	2.0-25.4	5/100	3.1	19.4	4.59	5.6	11.52	NA
Nickel	1.7-49.1	13/180	2.7	151	5.6	7.4	19.06	100
Potassium	763-2340	175/180	1,200	505,000	14,314	40,552	182,153	NA
Selenium-n	1.9-54	1/180	2.5	2.5	1.58	1.9	5.97	50
Silver-n	0.4-5.4	2/170	2.4	4.8	1.48	1.6	3.33	100
Sodium	NA	180/180	4,600	8,160,000	198,988	937,369	4,539,829	NA
Thallium-n	1.7-76	3/175	3.6	5.2	2.21	2.3	5.8	2
Vanadium	1.4-19.5	69/180	2	50.8	4.97	8.4	28.65	NA
Zinc	0.5-32.8	55/180	2.8	46,800	4.87	10.5	42.91	5,000

Notes:

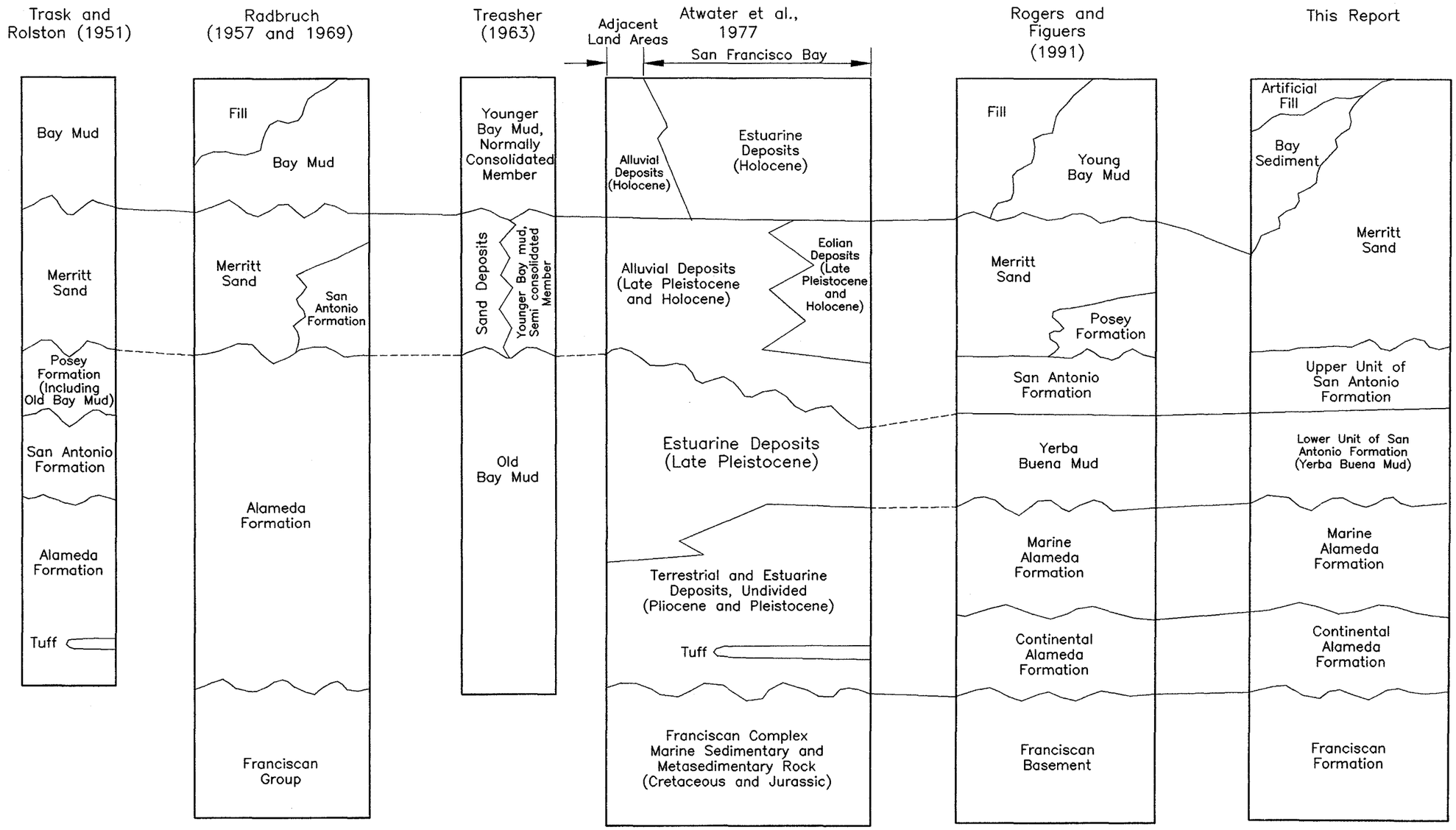
(a)	Statistics for chemicals denoted with "-n" are based on a normal distribution; too few detections were available to determine a probabile distribution.
(b)	Frequency of detection values are expressed as follows: number of samples in which chemical was detected/total number of samples for which chemical was analyzed.
(c)	Groundwater MCLs for a municipal supply are based on the "Water Quality Control Plan, San Francisco Bay Basin, Region 2 "Regional Water Quality Control Board (RWQCB 1995)
µg/L	Micrograms per liter
80 LCL/95 th Percentile	80 percent lower confidence limit on the 95th percentile of the distribution
95 UCL	95 percent upper confidence limit of the mean concentration
MCL	Maximum contaminant level
NA	Not applicable

SHORELINES.DWG – 05/14/99 – JHD – 044-0200IRRIRF



SOURCE: USGS, OAKLAND WEST, CALIFORNIA, QUADRANGLE

FIGURE 2-1
EXISTING AND OLD SHORELINES
FOR EAST BAY MARGIN
ALAMEDA POINT
ALAMEDA, CALIFORNIA

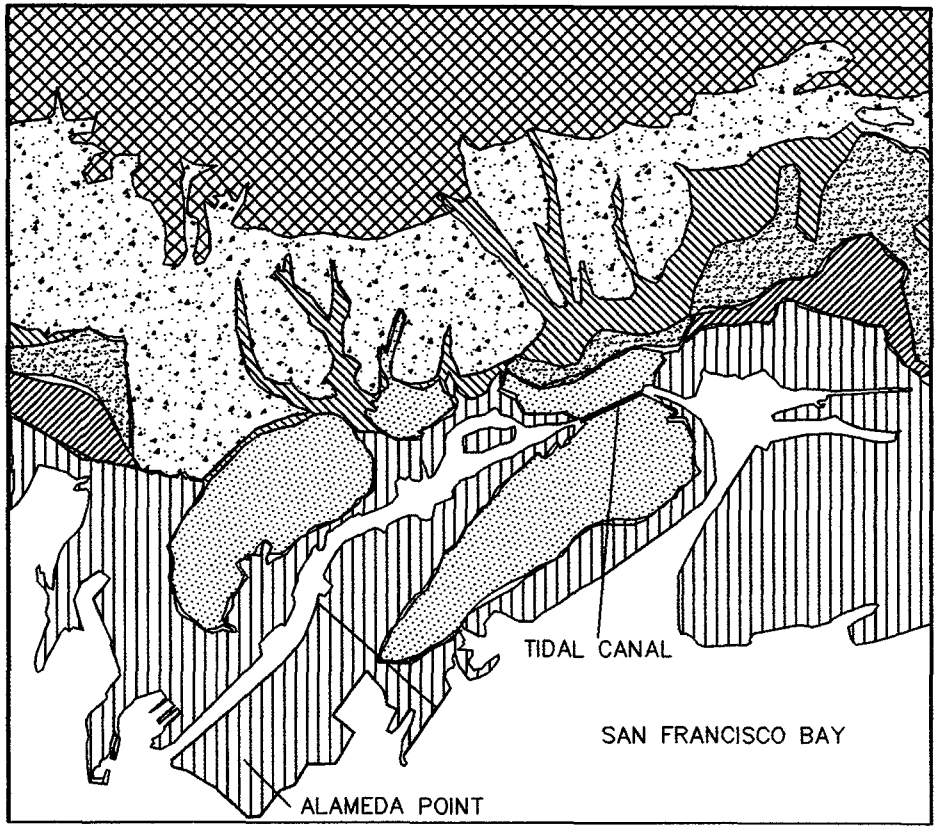


Notes:

1. Zig–Zag lines indicate interfingering of time–equivalent units.
2. Wavy lines indicate unconformities.

FIGURE 2-2
CORRELATION OF STRATIGRAPHIC INTERPRETATIONS
ALAMEDA POINT
ALAMEDA, CALIFORNIA

DATE: 05/13/99 MVT DN FILE NAME: R:\CAD\069\1669\0202\STRAT.DWG

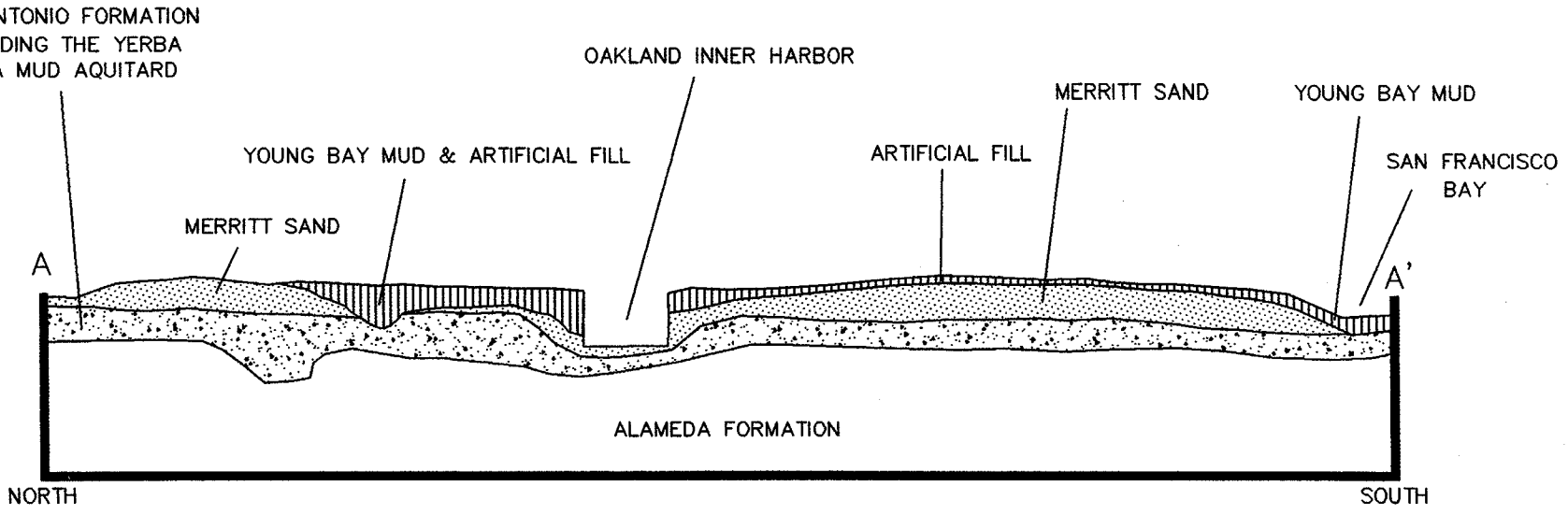


1 0 1 2
SCALE: 1" = 2 MILES

YOUNGER ALLUVIUM
TEMESCAL FORMATION
INTERFLUVIAL BASIN DEPOSITS
BAY MUD/ARTIFICIAL FILL
MERRITT SAND
SAN ANTONIO FORMATION
UNDIVIDED BEDROCK UNITS

FIGURE 2-3
EAST BAY MARGIN GEOLOGY
ALAMEDA POINT
ALAMEDA, CALIFORNIA

SOURCE: MODIFIED FROM RADBRUCH (1957, 1969)



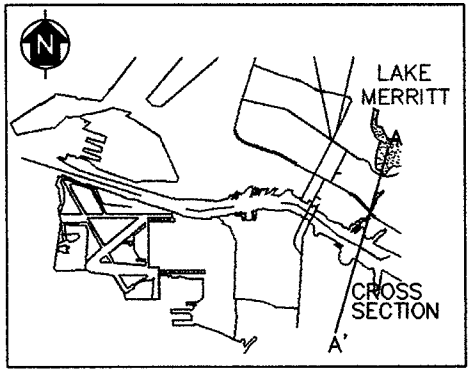
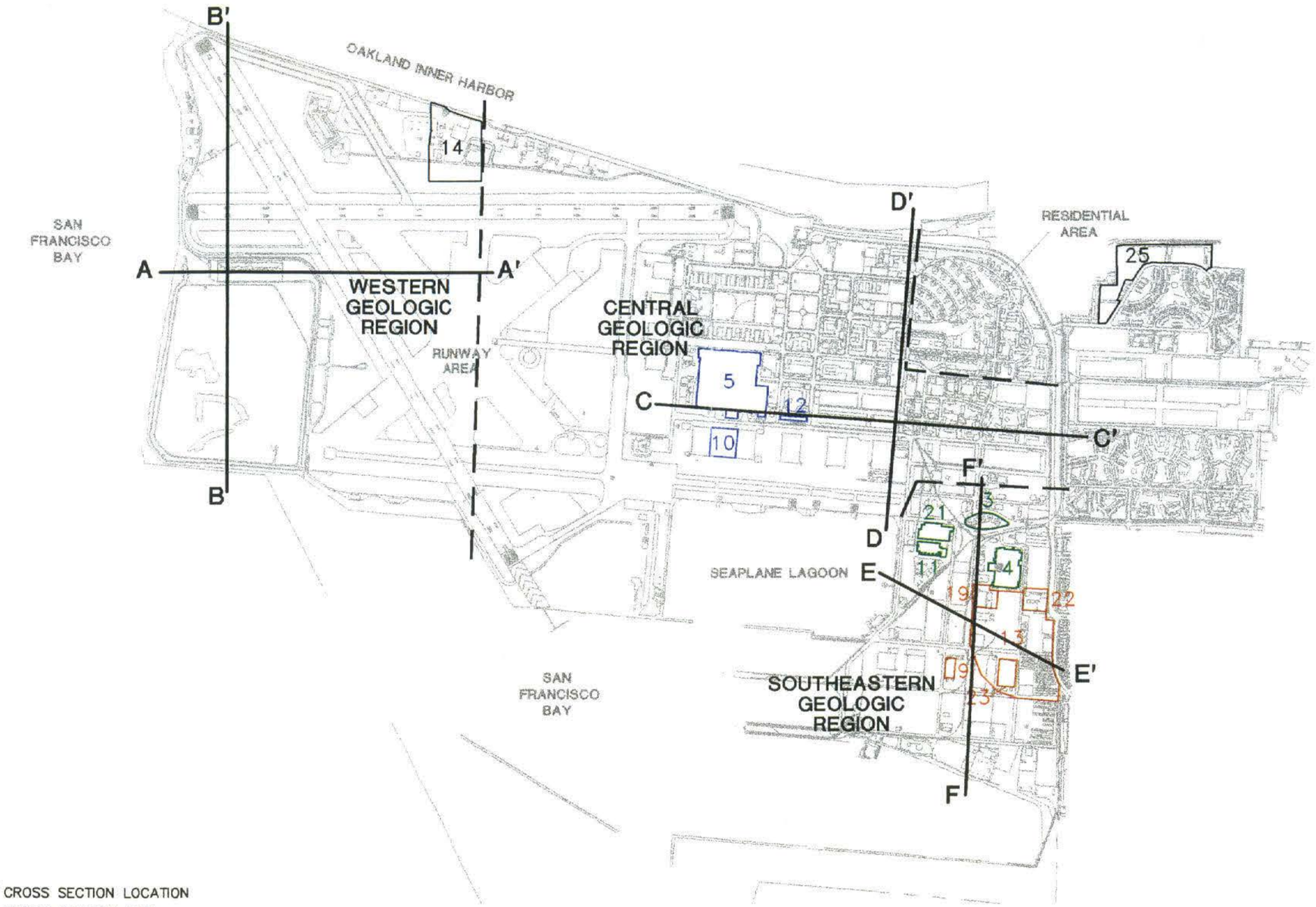


FIGURE 2-4
EAST BAY MARGIN HYDROSTRATIGRAPHY
ALAMEDA POINT
ALAMEDA, CALIFORNIA



LEGEND

A——A' CROSS SECTION LOCATION

— — — REGION DIVISION LINE

OU-2 CENTRAL AREA REGION INSTALLATION RESTORATION SITE BOUNDARY

OU-2 EASTERN AREA REGION INSTALLATION RESTORATION SITE BOUNDARY 3, 4, 11 and 21

OU-2 SOUTHEASTERN GEOLOGIC AREA INSTALLATION RESTORATION SITE BOUNDARY

750' 0 750' 1500'

SCALE: 1" = 1500'

FIGURE 2-5
GEOLOGIC REGIONS AND CROSS SECTION LOCATIONS
ALAMEDA POINT
ALAMEDA, CALIFORNIA

CS-LOC.DWG - 05/13/99 - MVT - 069\166B\0202\CS-LOC.DWG

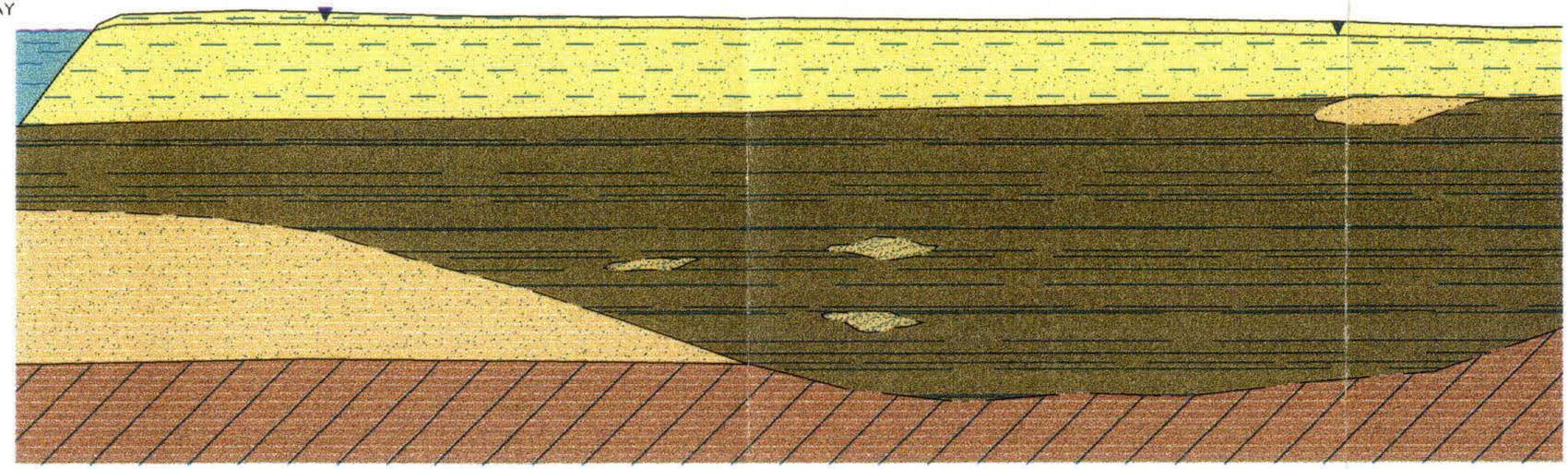
WEST

A

SAN FRANCISCO BAY

EAST

A'



SOUTH

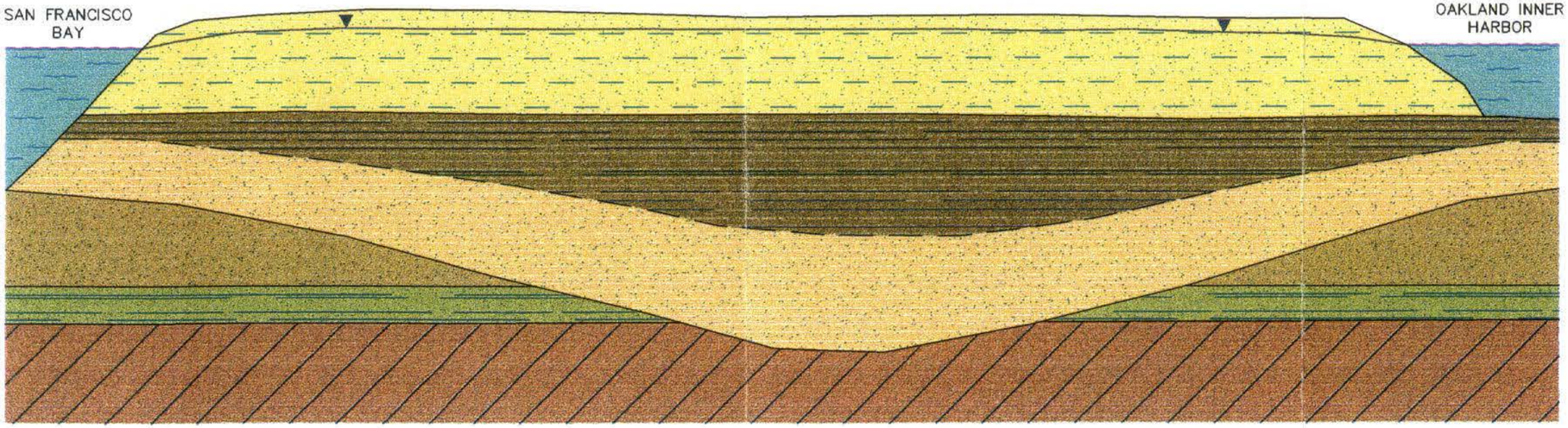
B

SAN FRANCISCO BAY

NORTH

B'

OAKLAND INNER HARBOR



LEGEND

- WATER BODIES
- FILL
- BAY SEDIMENTS CLAY
- BAY SEDIMENTS SAND
- MERRITT SAND
- SAN ANTONIO INTERBEDDED SAND AND CLAY
- YERBA BUENA MUD
- CONTACT OF LITHOLOGIC UNITS
- CONTACT OF FINE AND COARSE MATERIAL WITHIN BAY SEDIMENTS
- UNDEFINED CORRELATION
- FIRST WATER-BEARING ZONE WATER TABLE

NOT TO SCALE

FIGURE 2-6

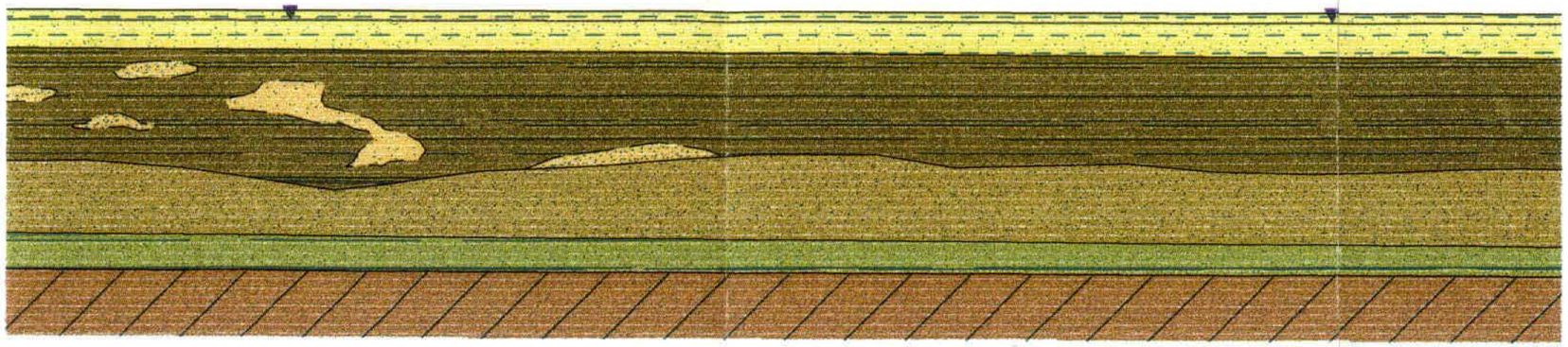
CONCEPTUAL GEOLOGY - WESTERN REGION
CROSS SECTIONS A-A' AND B-B'

ALAMEDA POINT
ALAMEDA, CALIFORNIA

FIGURE2-6.DWG - 03/25/96 - CFR - 044-0316RRRP

WEST
C

EAST
C'

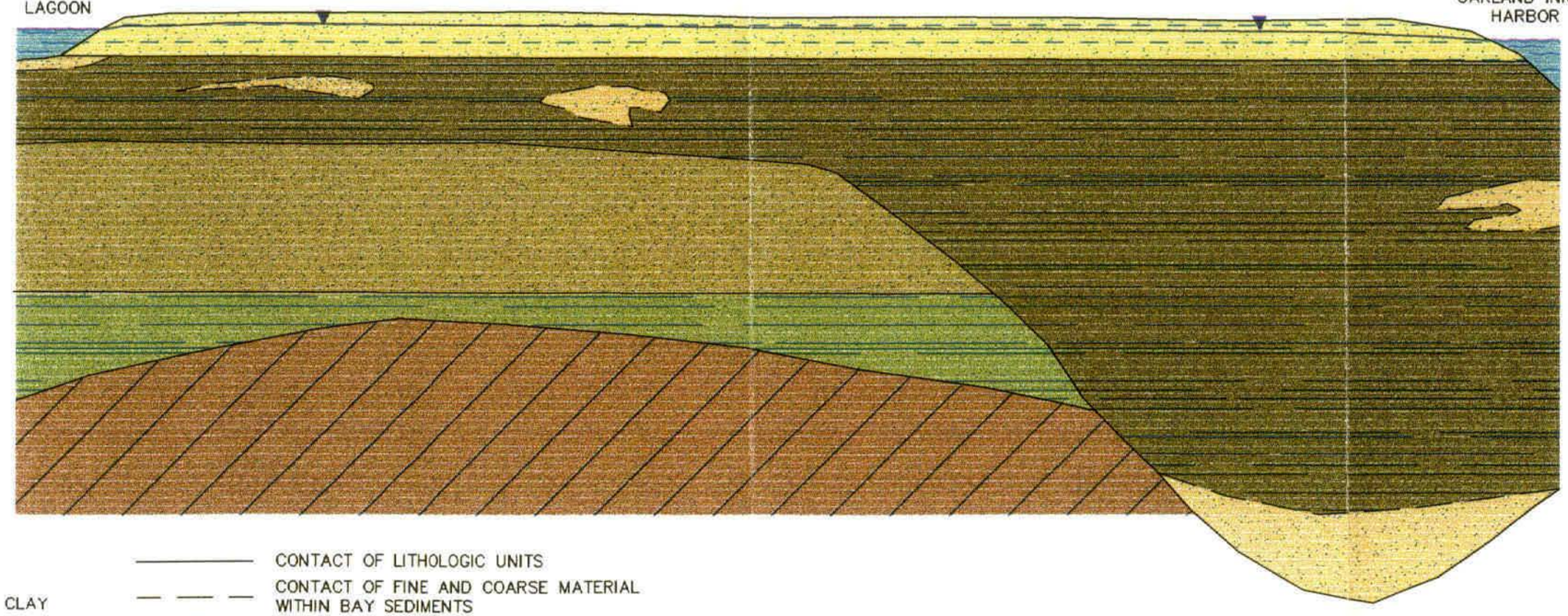


SOUTH
D

NORTH
D'

SEAPLANE LAGOON

OAKLAND INNER HARBOR



LEGEND

- WATER BODIES
- FILL
- BAY SEDIMENTS CLAY
- BAY SEDIMENTS SAND
- MERRITT SAND
- SAN ANTONIO INTERBEDDED SAND AND CLAY
- YERBA BUENA MUD

- CONTACT OF LITHOLOGIC UNITS
- CONTACT OF FINE AND COARSE MATERIAL WITHIN BAY SEDIMENTS
- FIRST WATER-BEARING ZONE WATER TABLE

NOT TO SCALE

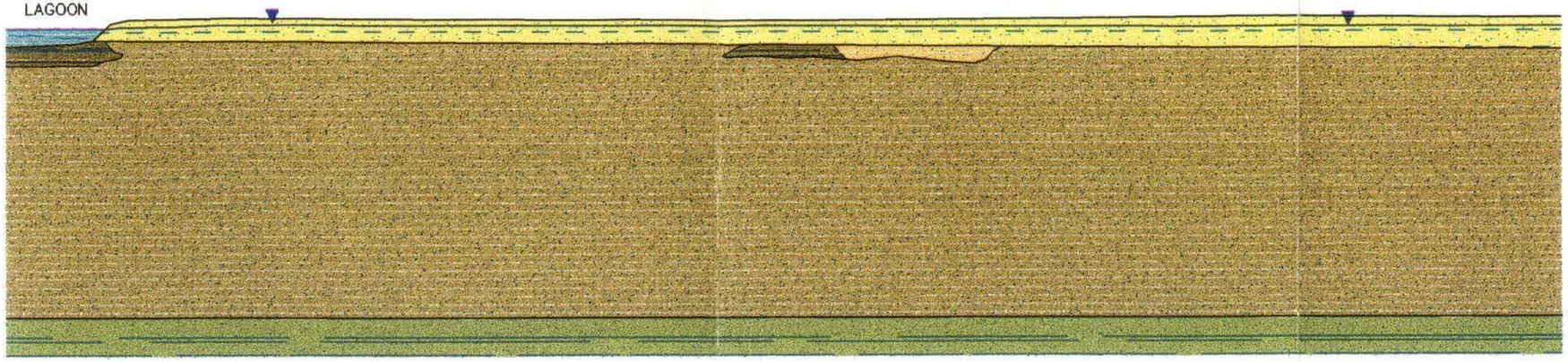
FIGURE 2-7
CONCEPTUAL GEOLOGY - CENTRAL REGION
CROSS-SECTIONS C-C' AND D-D'
ALAMEDA POINT
ALAMEDA, CALIFORNIA

FIGURE2-7.DWG - 03/19/98 - CFR - 044-0316RRRP

WEST
E

EAST
E'

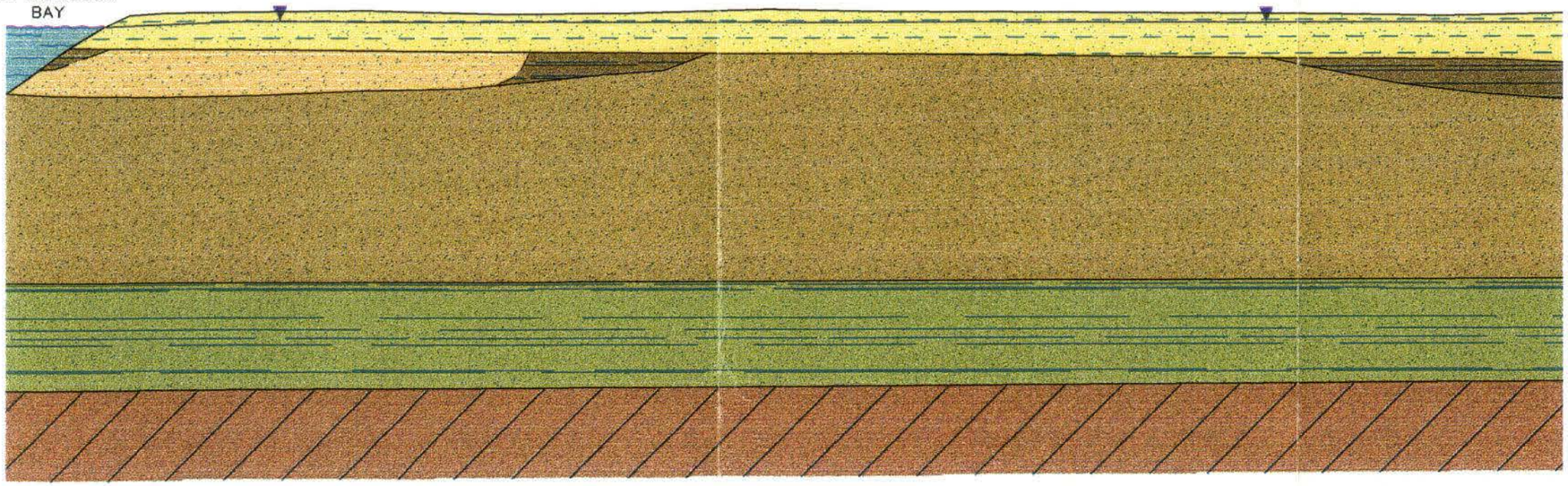
SEAPLANE LAGOON



SOUTH
F

NORTH
F'

SAN FRANCISCO BAY



LEGEND

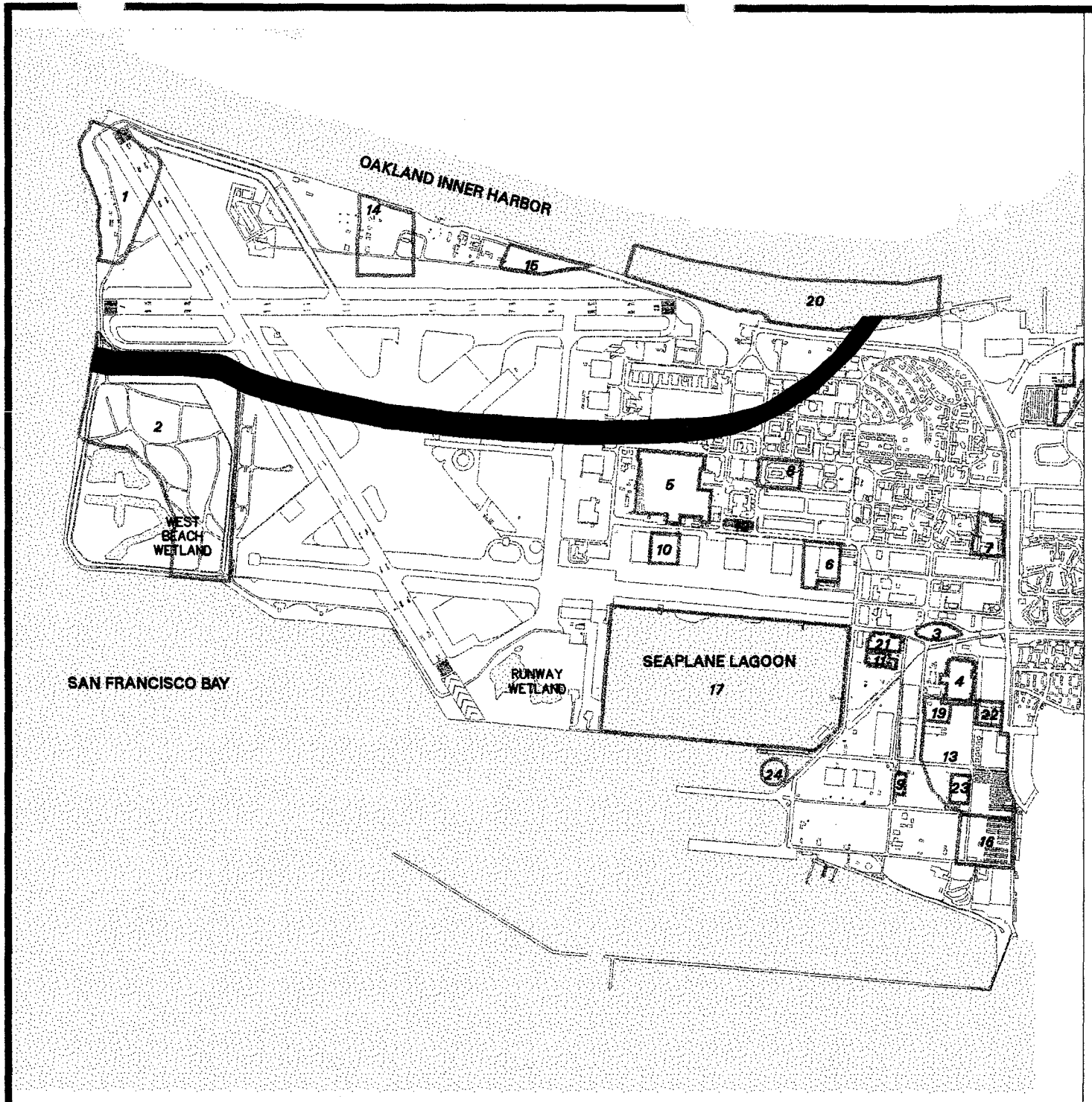
- WATER BODIES
- FILL
- BAY SEDIMENTS CLAY
- BAY SEDIMENTS SAND
- MERRITT SAND
- SAN ANTONIO INTERBEDDED SAND AND CLAY
- YERBA BUENA MUD

- CONTACT OF LITHOLOGIC UNITS
- CONTACT OF FINE AND COARSE MATERIAL WITHIN BAY SEDIMENTS
- SHALLOW WATER-BEARING ZONE WATER TABLE

NOT TO SCALE

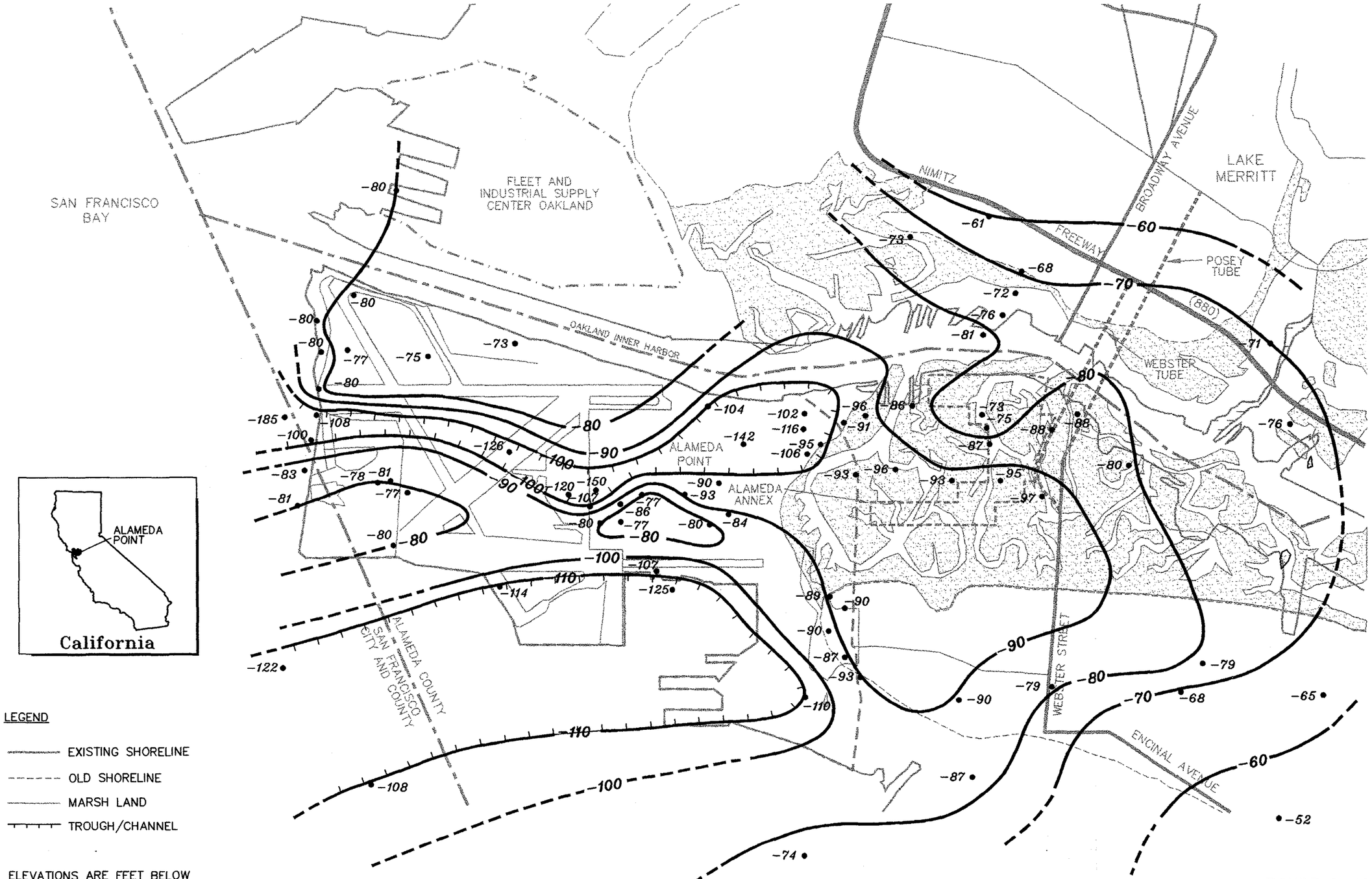
FIGURE 2-8
CONCEPTUAL GEOLOGY - SOUTHEASTERN REGION
CROSS SECTIONS E-E' AND F-F'
ALAMEDA POINT
ALAMEDA, CALIFORNIA

FIGURE2-8.DWG - 03/08/96 - CFR - 044-0316RIRP



08/29/98 /data3/alameda/amls/palechan3.map palechan3.aml AML

FIGURE 2-9
FORMER
PALEOCHANNEL LOCATION
ALAMEDA POINT
ALAMEDA, CALIFORNIA

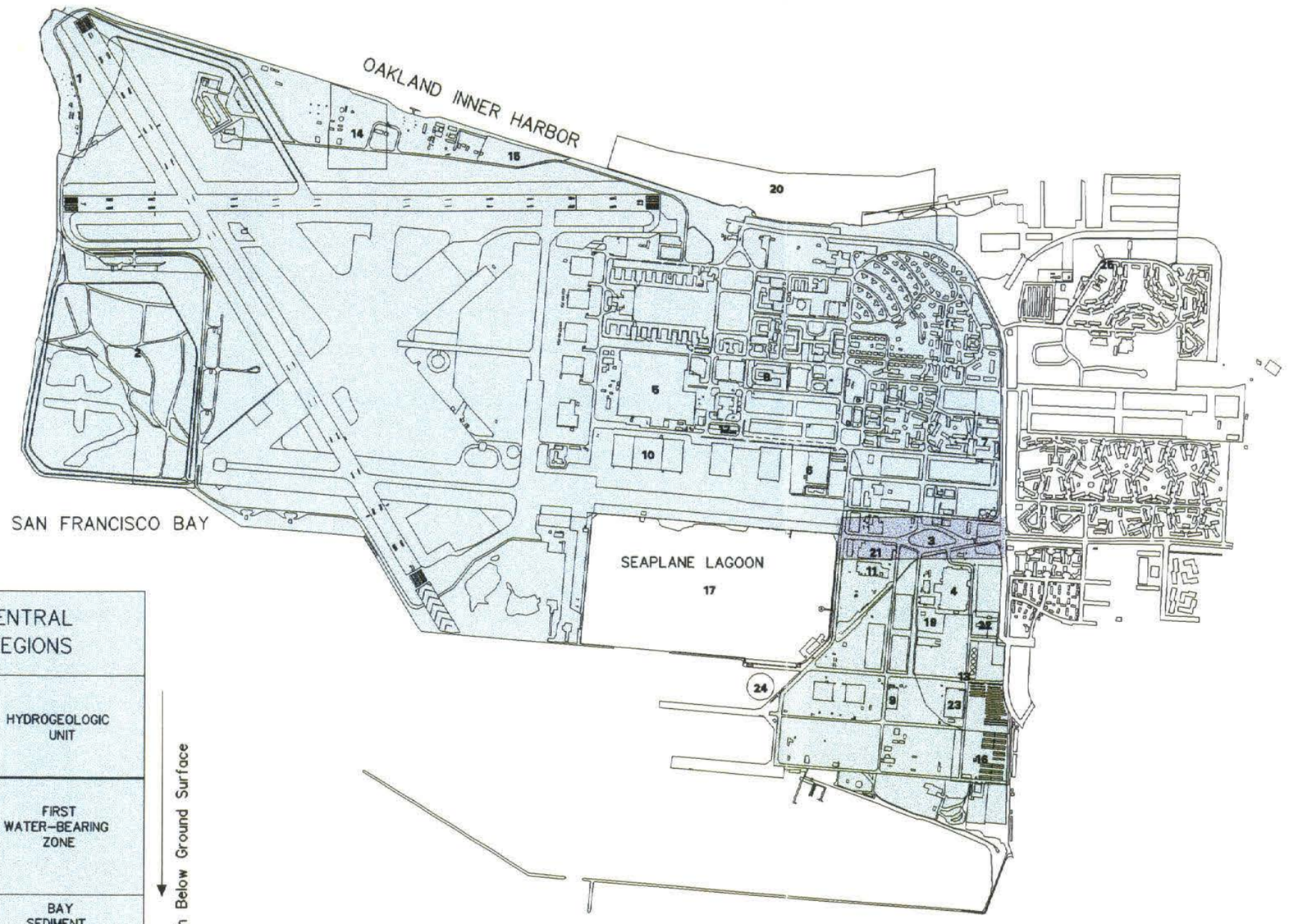


NOTE: ELEVATIONS ARE FEET BELOW MEAN LOWER LOW WATER

SOURCE: USGS, OAKLAND WEST, CALIFORNIA QUADRANGLE

FIGURE 2-10
SURFACE AND LATERAL EXTENT OF YERBA BUENA MUD
ALAMEDA POINT
ALAMEDA, CALIFORNIA

DATE: 08/17/98 MVT EN FILE NAME: R:\CAD\089\1668\0202\SURFACE.DWG



SOUTHEASTERN GEOLOGIC REGION		
LITHOSTRATIGRAPHIC UNIT		HYDROGEOLOGIC UNIT
FILL		FIRST WATER-BEARING ZONE
BAY SEDIMENTS / MERRITT SAND		
SAN ANTONIO FORMATION	UPPER SAN ANTONIO UNIT	
	YERBA BUENA MUD	YERBA BUENA MUD AQUITARD

Increasing Depth Below Ground Surface

WESTERN/CENTRAL GEOLOGIC REGIONS	
LITHOSTRATIGRAPHIC UNIT	HYDROGEOLOGIC UNIT
FILL	FIRST WATER-BEARING ZONE
BAY SEDIMENTS	BAY SEDIMENT UNIT
MERRITT SAND	SECOND WATER-BEARING ZONE
SAN ANTONIO FORMATION — UPPER SAN ANTONIO UNIT	
SAN ANTONIO FORMATION — YERBA BUENA MUD	YERBA BUENA MUD AQUITARD

Increasing Depth Below Ground Surface

NOTE:

THE FWBZU IN THE SOUTHEASTERN GEOLOGIC REGION COMMUNICATES WITH THE FWBZU IN THE CENTRAL GEOLOGIC REGION WHERE THE BAY SEDIMENT UNIT PINCHES OUT NEAR IR SITE 3. THE FWBZL IN THE SOUTHEASTERN GEOLOGIC REGION BECOMES AND COMMUNICATES WITH THE SWBZU IN THE CENTRAL GEOLOGIC REGION NORTH AND WEST OF IR SITE 3.

ACRONYMS:
FWBZU – FIRST WATER-BEARING ZONE UPPER
FWBZL – FIRST WATER-BEARING ZONE LOWER

LEGEND:

- WESTERN/CENTRAL GEOLOGIC REGIONS
- SOUTHEASTERN GEOLOGIC REGION
- BAY SEDIMENT UNIT

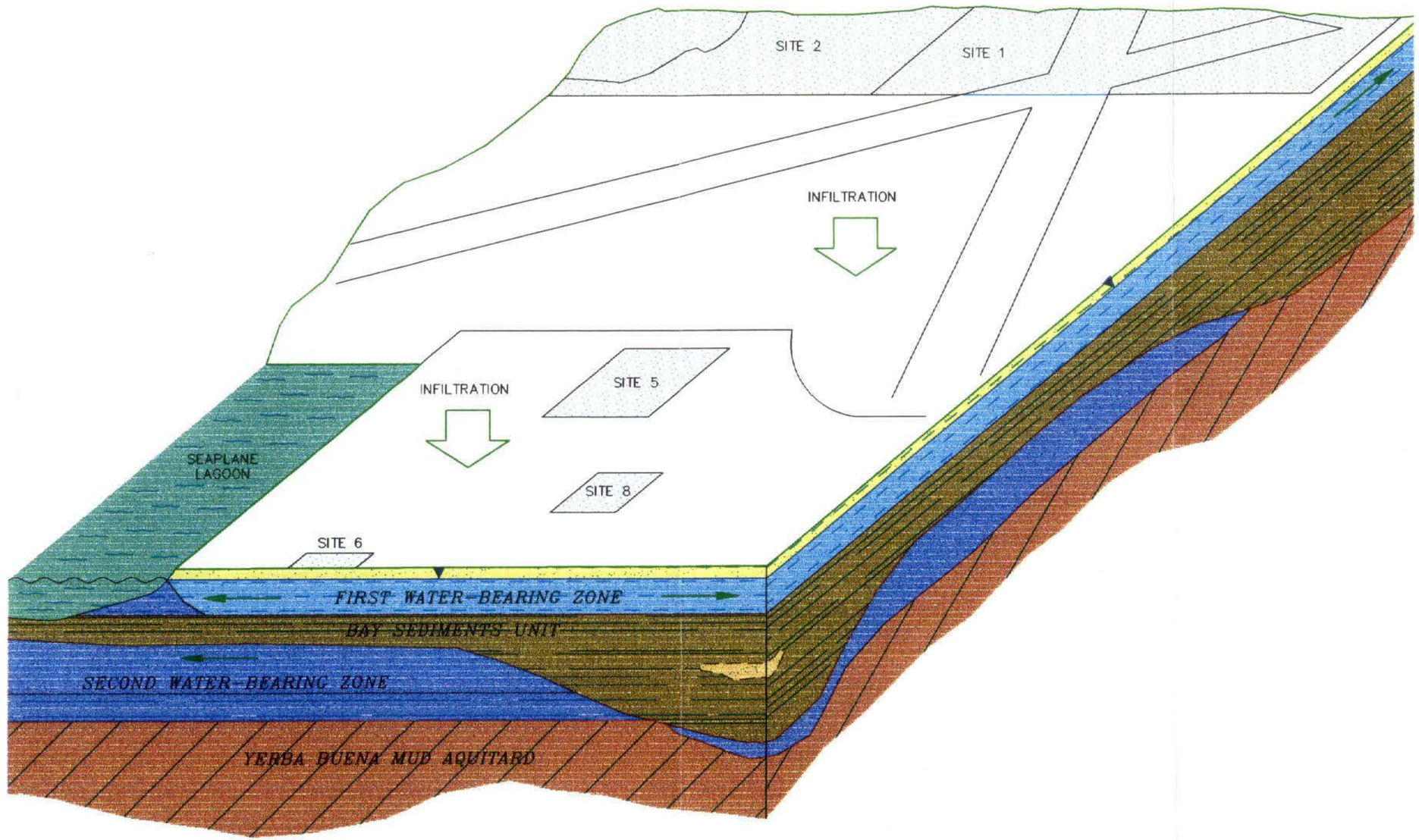
N

750 0 750 1500

SCALE: 1" = 1500'

FIGURE 2-11
CORRELATION OF HYDROGEOLOGIC UNITS BETWEEN GEOLOGIC REGIONS
ALAMEDA POINT
ALAMEDA, CALIFORNIA

05/13/99 /ta3/alameda/outri/hygeo3.aml Bob



LEGEND

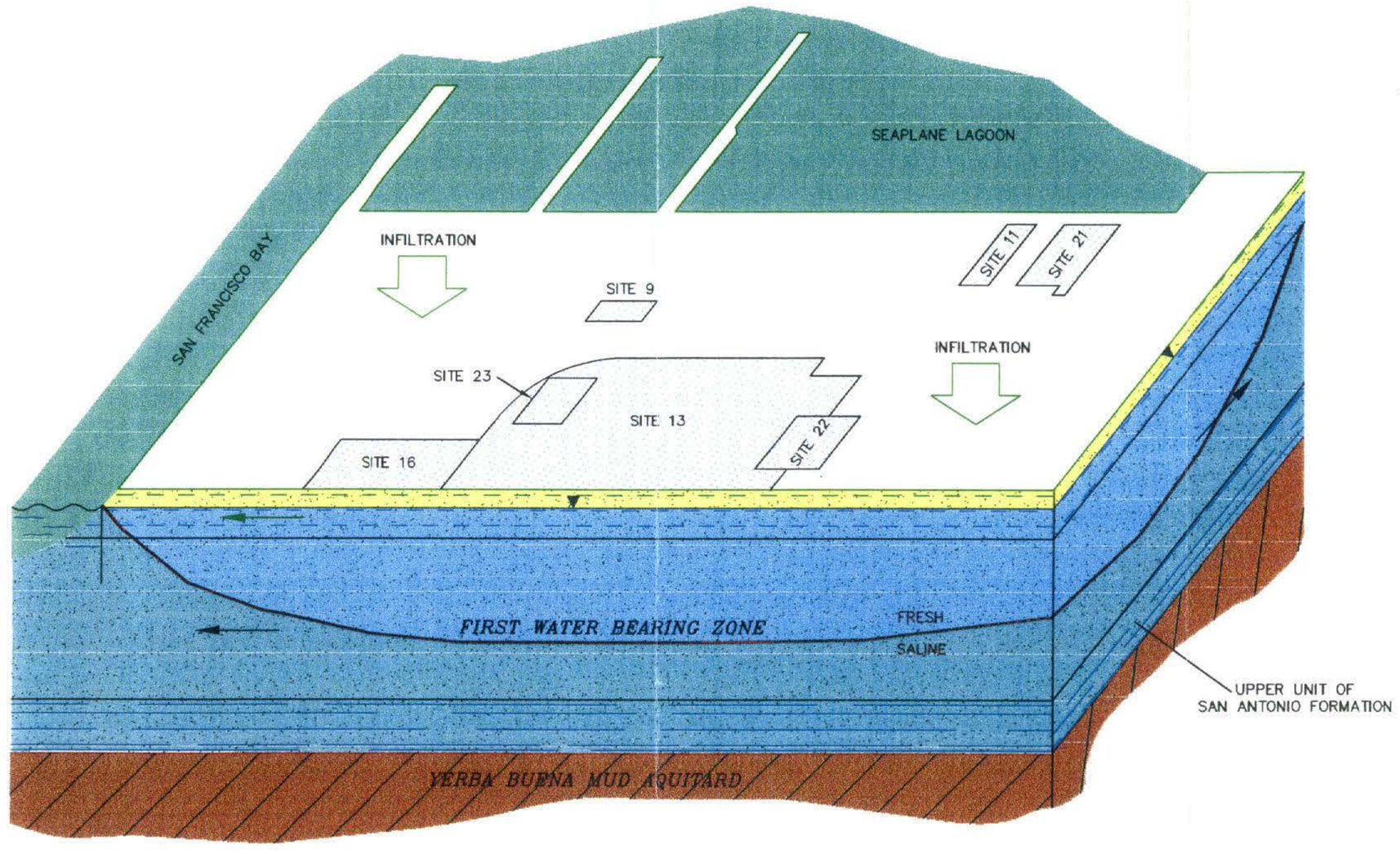
- SEA WATER
- ARTIFICIAL FILL WITH FRESH GROUNDWATER
- BAY SEDIMENTS CLAY
- BAY SEDIMENTS SAND
- MERRITT SAND WITH SALINE GROUNDWATER
- SAN ANTONIO INTERBEDDED SAND AND CLAY WITH SALINE GROUNDWATER
- YERBA BUENA MUD AQUITARD

- CONTACT OF LITHOLOGIC UNITS
- CONTACT OF FINE AND COARSE MATERIAL WITHIN BAY SEDIMENTS
- FIRST WATER-BEARING ZONE WATER TABLE
- GROUNDWATER FLOW DIRECTION
- FRESHWATER/SALTWATER INTERFACE
- IR SITE

NOT TO SCALE

FIGURE 2-12
HYDROGEOLOGIC CONCEPTUAL MODEL
FOR THE WESTERN AND CENTRAL REGIONS
ALAMEDA POINT
ALAMEDA, CALIFORNIA

FIGURE2-15.DWG - 08/14/98 - JHD- 044-0316IRRIRP



LEGEND

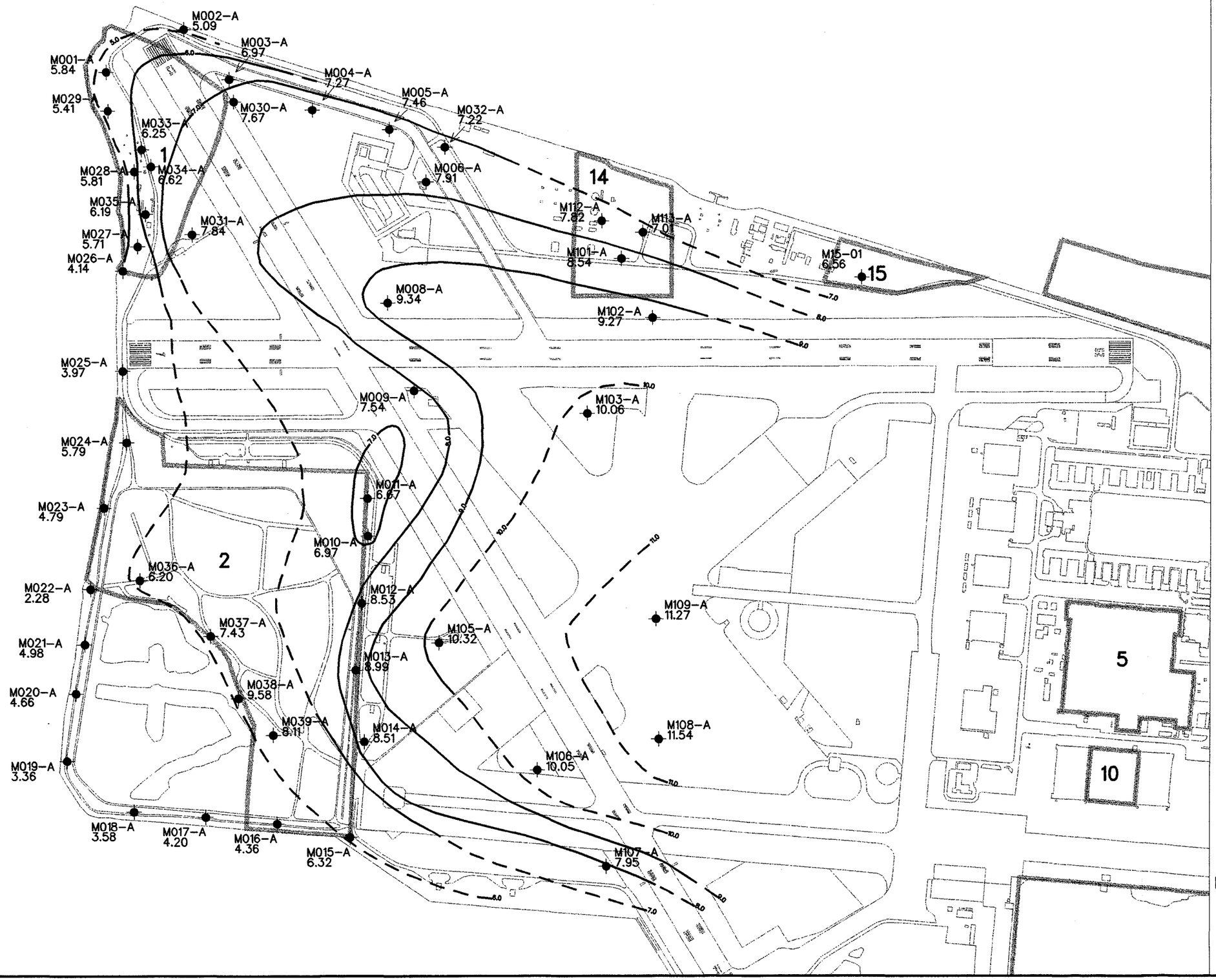
- INSTALLATION RESTORATION SITE
- SEAWATER
- ARTIFICIAL FILL WITH FRESH WATER
- MERRITT SAND WITH FRESH WATER
- MERRITT SAND WITH SALINE WATER
- UPPER UNIT OF SAN ANTONIO FORMATION WITH SALINE WATER
- YERBA BUENA MUD AQUITARD

- CONTACT OF LITHOLOGIC UNITS
- FIRST WATER-BEARING ZONE WATER TABLE
- GROUNDWATER FLOW DIRECTION
- FRESHWATER/SALTWATER INTERFACE

NOT TO SCALE

FIGURE 2-13
HYDROGEOLOGIC
CONCEPTUAL MODEL
SOUTHEASTERN GEOLOGIC REGION
ALAMEDA POINT
ALAMEDA, CALIFORNIA

05/13/99 KEN DW O:\ALAMEDA\BEN4-17.DWG



LEGEND

- ✦ MONITORING WELL
- ⊗ PIEZOMETER
- 4.21 GROUNDWATER ELEVATION (FEET ABOVE MEAN LOWER LOW WATER)
- 8 INSTALLATION RESTORATION SITE
- —4.5— WATER ELEVATION CONTOUR IN FEET (MEAN LOWER LOW WATER), DASHED WHERE INFERRED

NOTE: POTENTIOMETRIC SURFACE MAP BASED ON APRIL 1998 TIDALLY CORRECTED GROUNDWATER ELEVATION DATA.

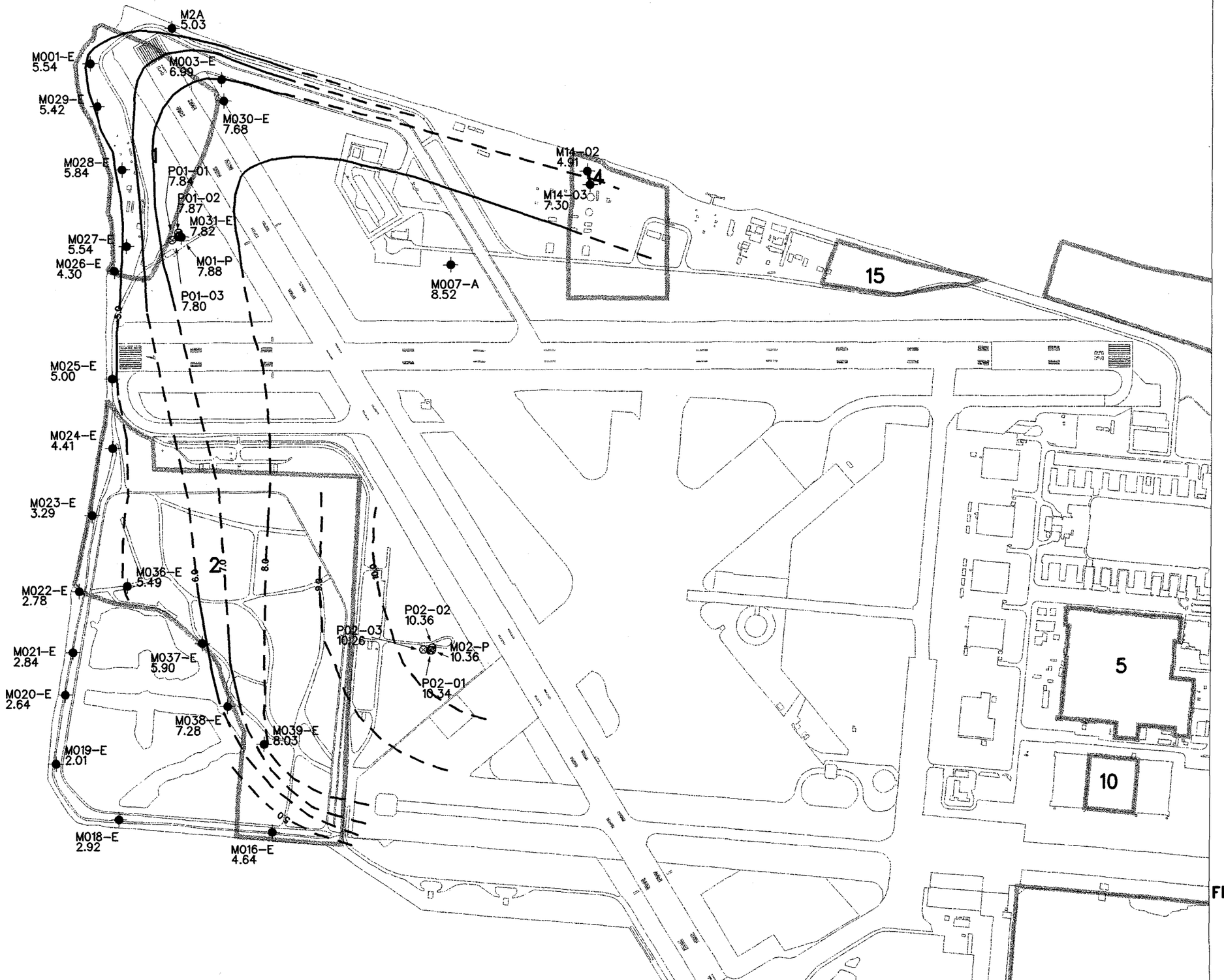
N

350 0 350 700

SCALE: 1" = 700'

FIGURE 2-14a
POTENTIOMETRIC SURFACE MAP-FIRST WATER-BEARING ZONE UPPER WESTERN GEOLOGIC REGION
ALAMEDA POINT
ALAMEDA, CALIFORNIA

05/13/99 /data3/home/scottr/may98gw.aml FWBZUWEST may98.mxp relate table /DATA3/HOME/SCOTTP ARCIMAY98GW BB



LEGEND

- ✦ MONITORING WELL
- ⊗ PIEZOMETER
- 4.21 GROUNDWATER ELEVATION (FEET ABOVE MEAN LOWER LOW WATER)
- 8 INSTALLATION RESTORATION SITE
- —4.5— WATER ELEVATION CONTOUR IN FEET (MEAN LOWER LOW WATER), DASHED WHERE INFERRED

NOTE: POTENTIOMETRIC SURFACE MAP BASED ON APRIL 1998 TIDALLY CORRECTED GROUNDWATER ELEVATION DATA.

N

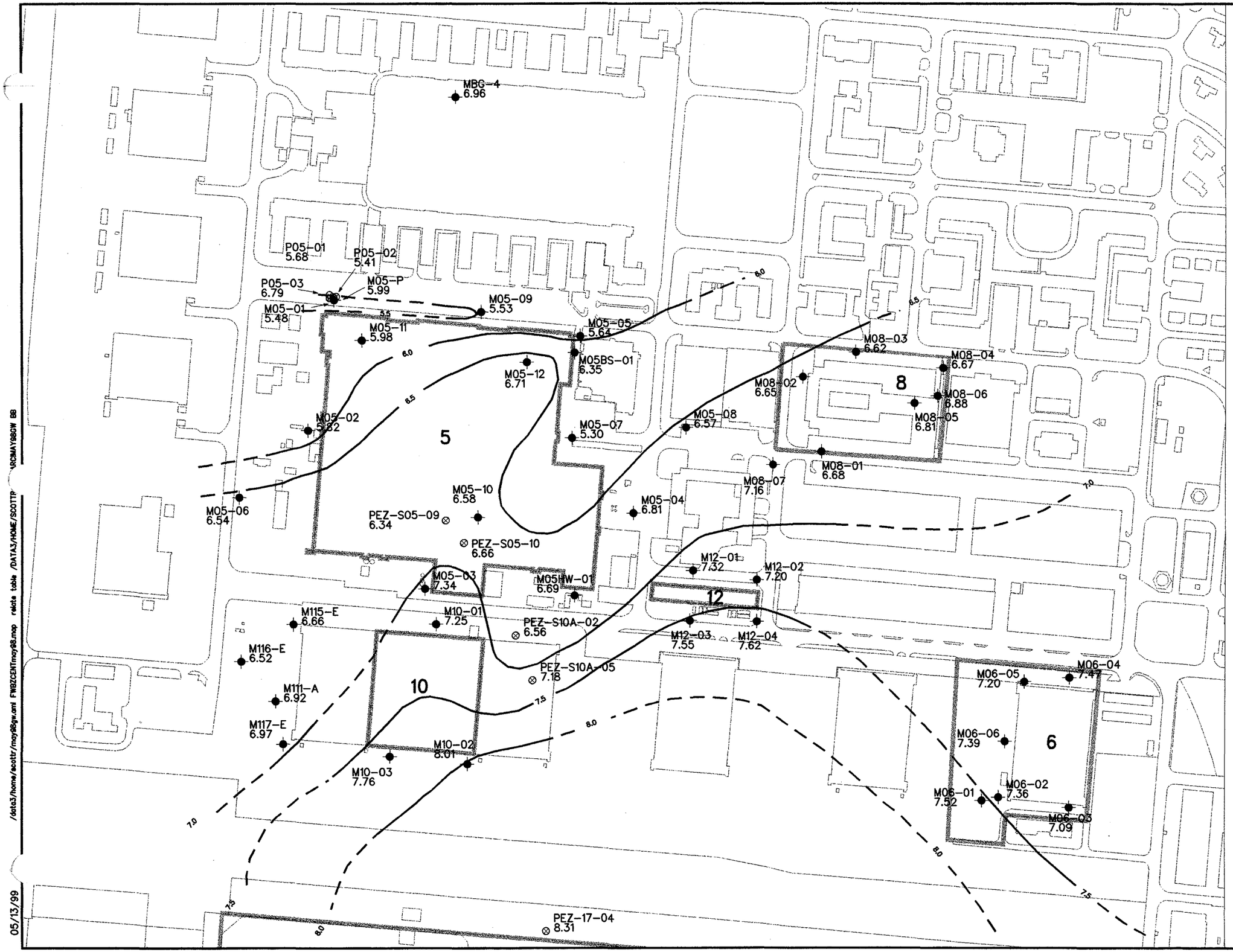
350 0 350 700

SCALE: 1" = 700'

FIGURE 2-14b
POTENTIOMETRIC SURFACE MAP-FIRST WATER-BEARING ZONE LOWER WESTERN GEOLOGIC REGION
ALAMEDA POINT
ALAMEDA, CALIFORNIA

/data3/home/scottr/may98gw.eml FWBZLWESTmay98.map relate table /DATA3/HOME/SCOTT\RCMAY98GW BB

05/13/99



LEGEND

- ✦ MONITORING WELL
- ⊗ PIEZOMETER
- 4.21 GROUNDWATER ELEVATION (FEET ABOVE MEAN LOWER LOW WATER)
- 8 INSTALLATION RESTORATION SITE
- —4.5— WATER ELEVATION CONTOUR IN FEET (MEAN LOWER LOW WATER), DASHED WHERE INFERRED

NOTE: POTENTIOMETRIC SURFACE MAP BASED ON APRIL 1998 TIDALLY CORRECTED GROUNDWATER ELEVATION DATA.

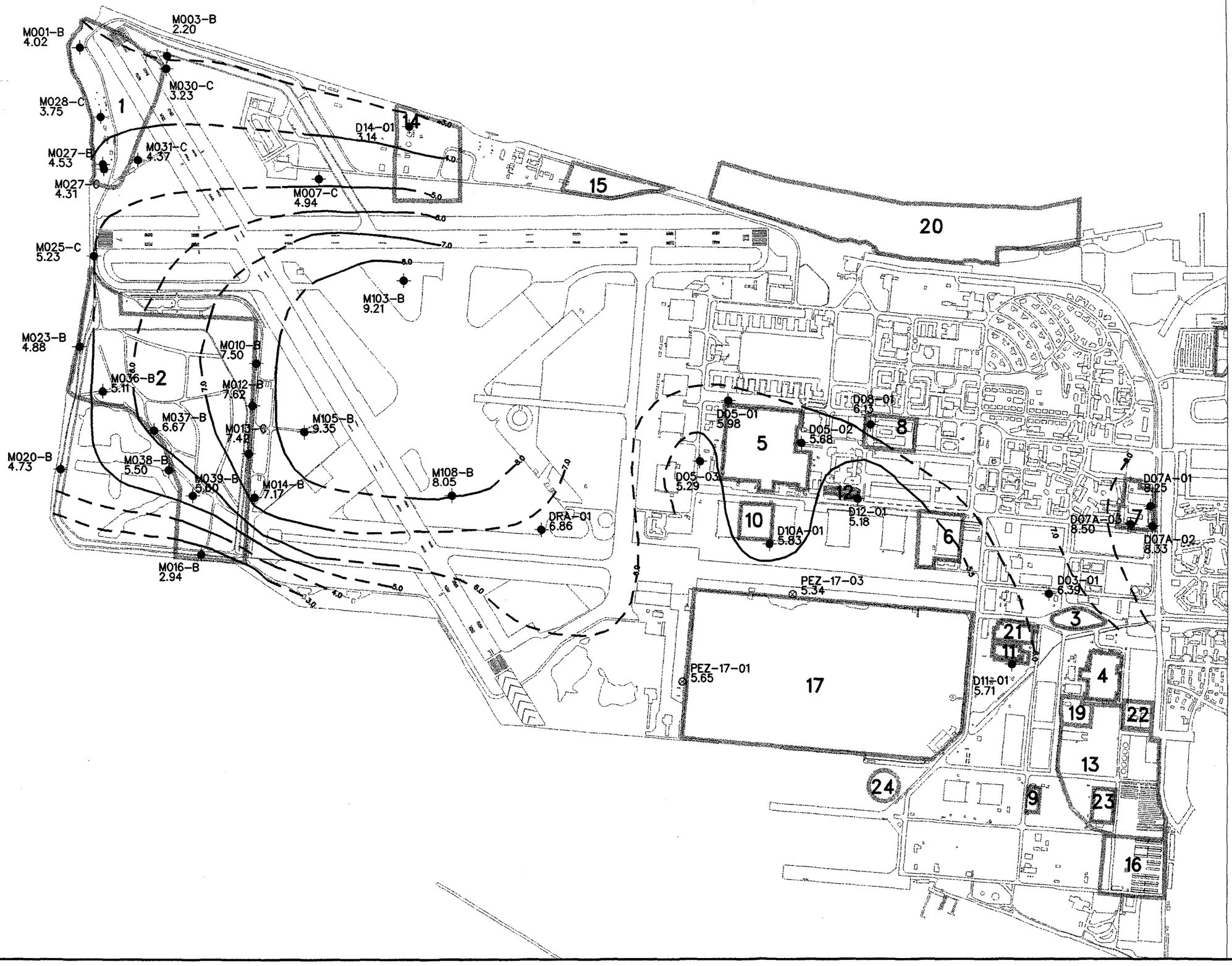
N

150 0 150 300

SCALE: 1" = 300'

FIGURE 2-14c
POTENTIOMETRIC SURFACE MAP-FIRST WATER-BEARING ZONE CENTRAL GEOLOGIC REGION
ALAMEDA POINT
ALAMEDA, CALIFORNIA

05/13/99 /data3/home/scottr/may98gw.aml FWBZCENTmay98.map relate table /DATA3/HOME/SCOTTR/RC&MAY98GW BB



LEGEND

- MONITORING WELL
- PIEZOMETER
- 4.21 GROUNDWATER ELEVATION (FEET ABOVE MEAN LOWER LOW WATER)
- 8 INSTALLATION RESTORATION SITE
- —4.5— WATER ELEVATION CONTOUR IN FEET (MEAN LOWER LOW WATER), DASHED WHERE INFERRED

NOTE: POTENTIOMETRIC SURFACE MAP BASED ON APRIL 1998 TIDALLY CORRECTED GROUNDWATER ELEVATION DATA.

N

500 0 500 1000

SCALE: 1" = 1000'

FIGURE 2-14d
BASEWIDE
POTENTIOMETRIC SURFACE MAP-
SECOND WATER-BEARING ZONE
UPPER
ALAMEDA POINT
ALAMEDA, CALIFORNIA

/data3/home/scottr/may98gw.mxd SWBZALL.may98.mxp relate table /DATA3/HOME/SCOTTR/ROMAY98GW.BB

05/13/99

LEGEND

- MONITORING WELL
- PIEZOMETER
- 4.21 GROUNDWATER ELEVATION (FEET ABOVE MEAN LOWER LOW WATER)
- 8 INSTALLATION RESTORATION SITE
- —4.5— WATER ELEVATION CONTOUR IN FEET (MEAN LOWER LOW WATER), DASHED WHERE INFERRED

NOTE: POTENTIOMETRIC SURFACE MAP BASED ON APRIL 1998 TIDALLY CORRECTED GROUNDWATER ELEVATION DATA.

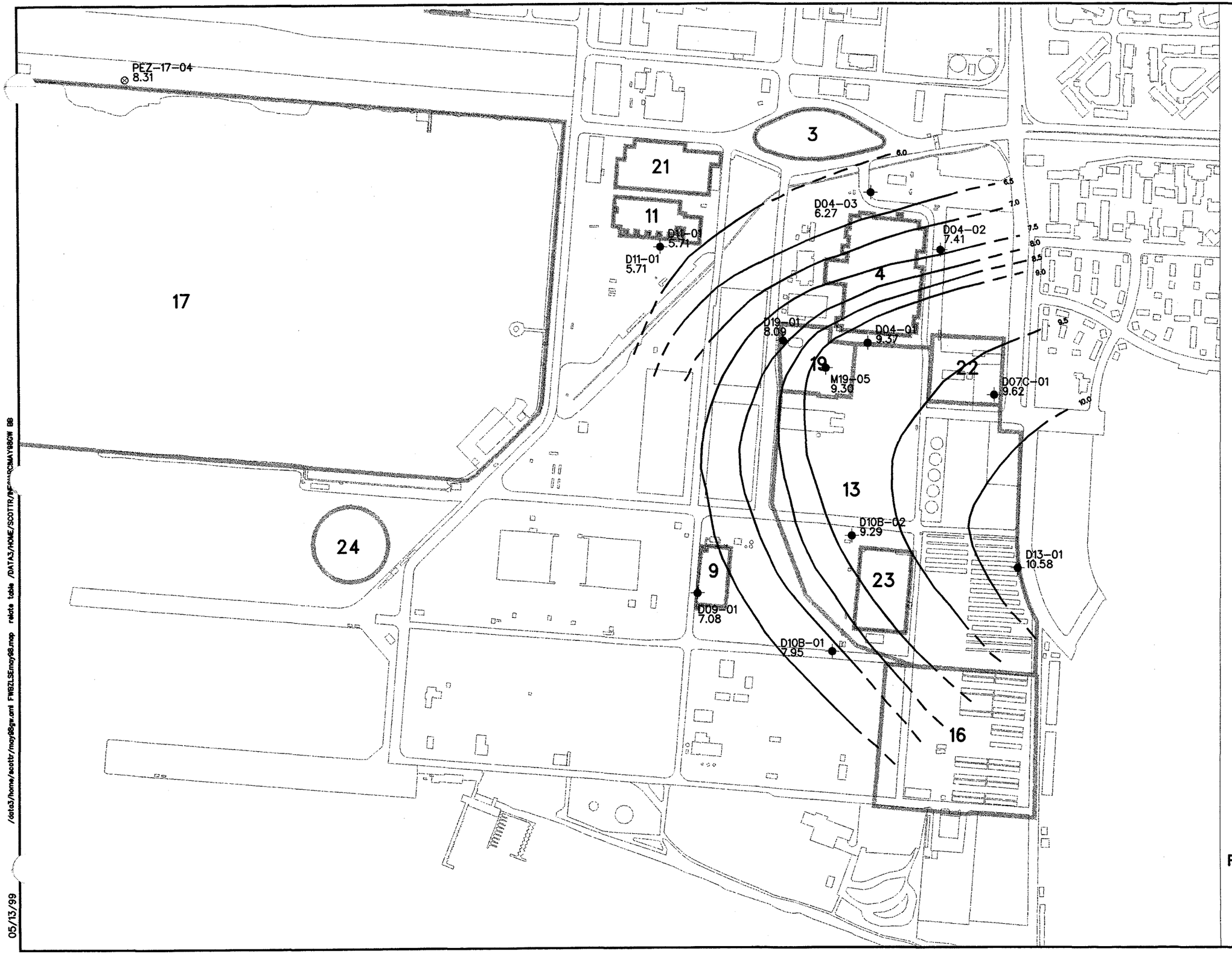
300 0 300 600

SCALE: 1" = 600'

FIGURE 2-14e
POTENTIOMETRIC SURFACE MAP-FIRST WATER-BEARING ZONE UPPER SOUTHEASTERN GEOLOGIC REGION
ALAMEDA POINT
ALAMEDA, CALIFORNIA

/data3/home/scottr/may98gw.eml FWB2USEmay98.mxp relate table /DATA3/HOME/SCOTTR/MAY98GW BB

05/13/99



LEGEND

- ⌖ MONITORING WELL
- ⊗ PIEZOMETER
- 4.21 GROUNDWATER ELEVATION (FEET ABOVE MEAN LOWER LOW WATER)
- 8 INSTALLATION RESTORATION SITE
- —4.5— WATER ELEVATION CONTOUR IN FEET (MEAN LOWER LOW WATER), DASHED WHERE INFERRED

NOTE: POTENTIOMETRIC SURFACE MAP BASED ON APRIL 1998 TIDALLY CORRECTED GROUNDWATER ELEVATION DATA.

N

200 0 200 400

SCALE: 1" = 400'

FIGURE 2-14f
POTENTIOMETRIC SURFACE MAP-FIRST WATER-BEARING ZONE LOWER SOUTHEASTERN GEOLOGIC REGION
ALAMEDA POINT
ALAMEDA, CALIFORNIA

05/13/99 /data3/home/scottr/may98gw.aml FWBZLSEmay98.map relate table /DATA3/HOME/SCOTTR/[illegible]RCBMAY98GW BB

LEGEND

- INSTALLATION RESTORATION SITE
- < 500 mg/L TDS
- 500–3,000 mg/L TDS
- > 3,000 mg/L TDS
- — — GEOLOGIC REGION BOUNDARY

NOTES:

BASED ON AVERAGE TDS VALUES FOR SAMPLES COLLECTED DURING QUARTERLY IN 1994 AND 1995.

THE FWBZ IN THE WESTERN AND CENTRAL GEOLOGIC REGIONS IS PRIMARILY FILL. THE FWBZ IN THE SOUTHEASTERN GEOLOGIC REGION IS DEFINED TO BE LESS THAN 30 FEET BGS IN THIS FIGURE.

ACRONYMS:

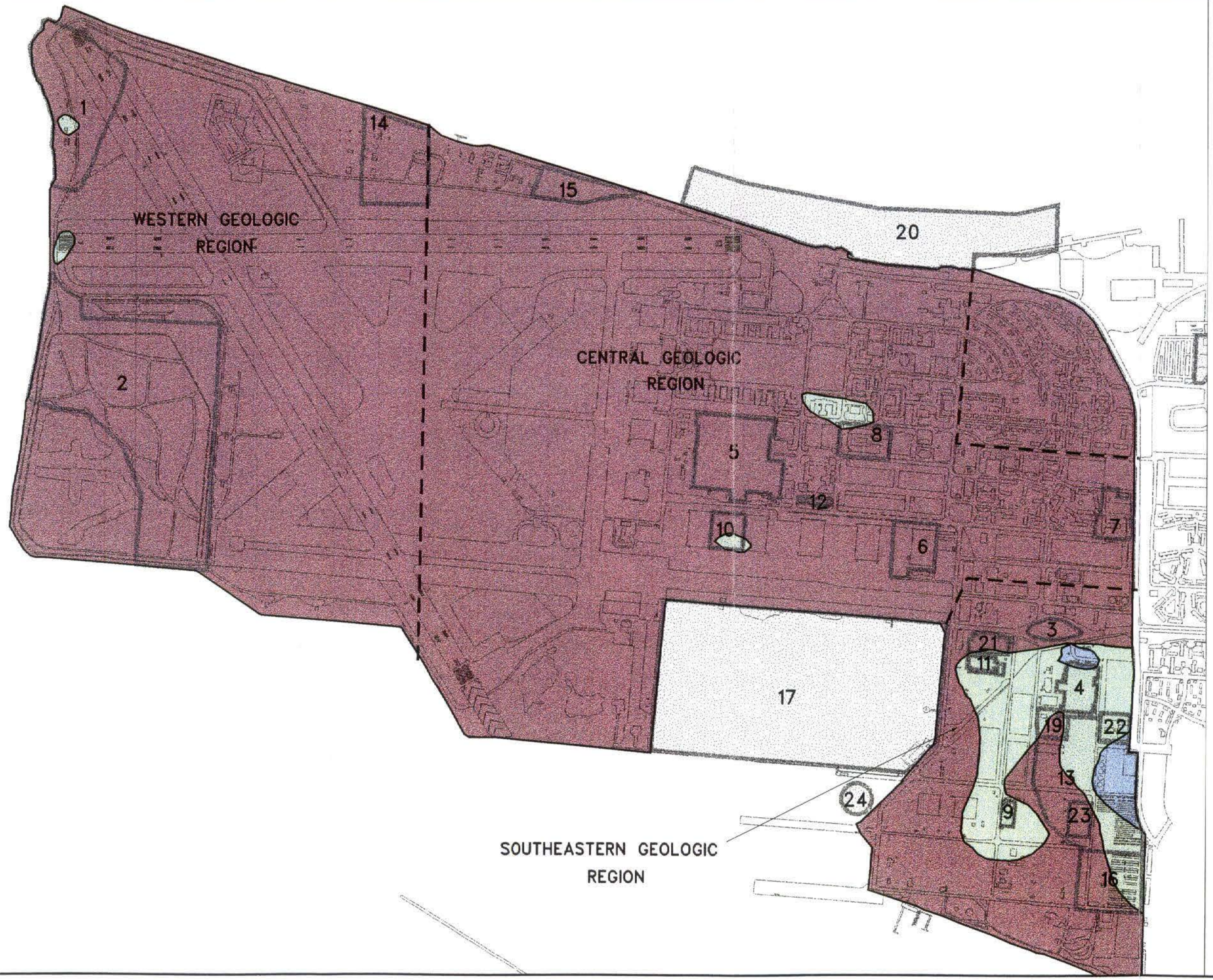
BGS – BELOW GROUND SURFACE
FWBZ – FIRST WATER BEARING ZONE
mg/L – MILLIGRAMS PER LITER
TDS – TOTAL DISSOLVED SOLIDS

N

500 0 500 1000
SCALE: 1" = 1000'

FIGURE 2–15
APPROXIMATE EXTENT OF FRESHWATER IN THE FIRST WATER–BEARING ZONE
ALAMEDA POINT
ALAMEDA, CALIFORNIA

05/13/99 /data3/home/ecottr/dotda.aml dotdaup4.mxp RJF



LEGEND

- INSTALLATION RESTORATION SITE
- < 500 mg/L TDS
- 500–3,000 mg/L TDS
- > 3,000 mg/L TDS
- GEOLOGIC REGION BOUNDARY

NOTES:

BASED ON AVERAGE TDS VALUES IN SAMPLES COLLECTED DURING QUARTERLY SAMPLING IN 1994 AND 1995.

THE SWBZ IN THE SOUTHEASTERN GEOLOGIC INCLUDES DATA IN THE MERRITT SAND AQUIFER FROM GREATER THAN 30 FEET BGS.

ACRONYMS:

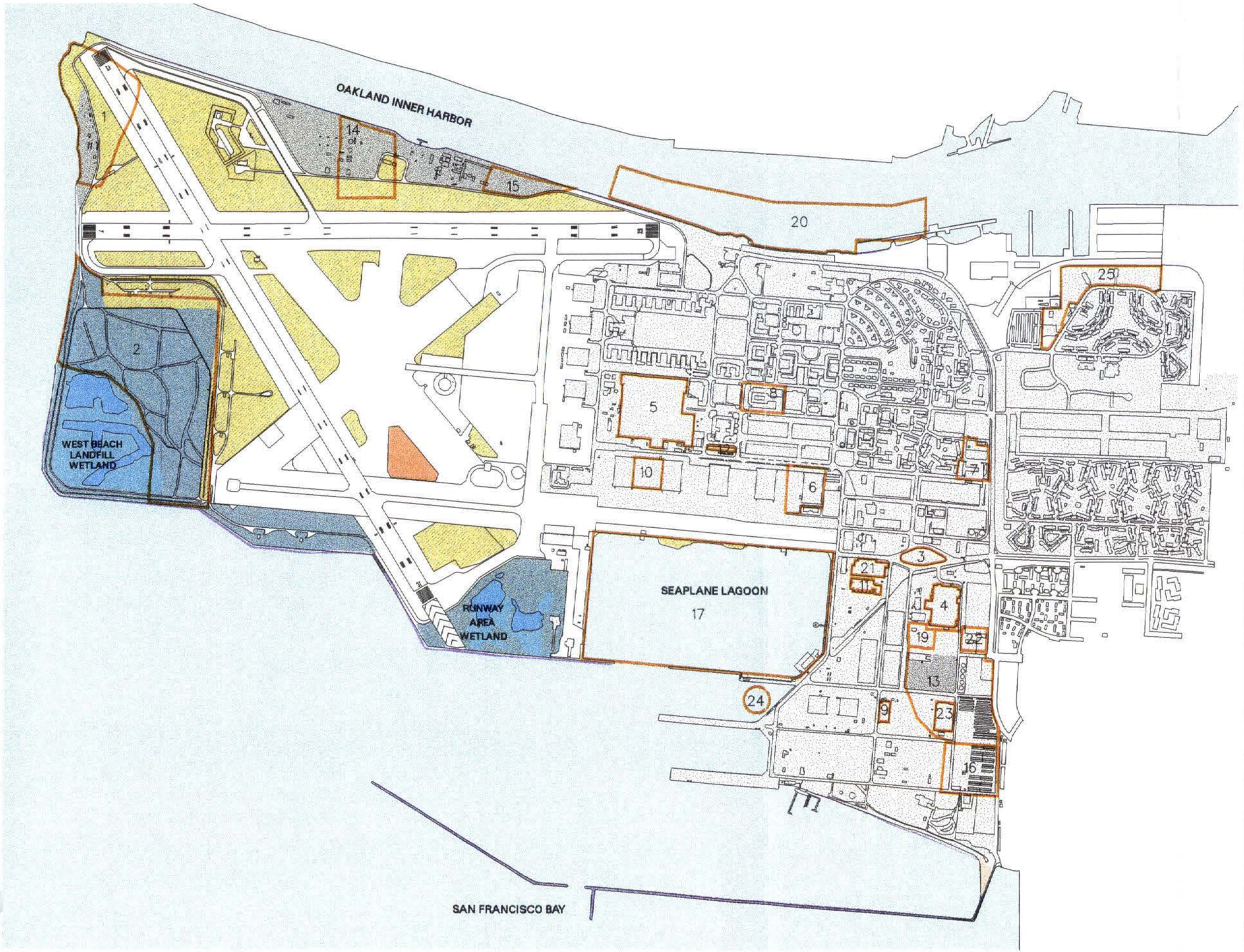
BGS – BELOW GROUND SURFACE
mg/L – MILLIGRAMS PER LITER
SWBZ – SECOND WATER BEARING ZONE
TDS – TOTAL DISSOLVED SOLIDS

N

500 0 500 1000
SCALE: 1" = 1000'

FIGURE 2–16
APPROXIMATE EXTENT OF FRESHWATER IN THE SECOND WATER-BEARING ZONE
ALAMEDA POINT
ALAMEDA, CALIFORNIA

/data3/home/scottr/alotda.eml alotdaloe4.map RJF
05/13/99



LEGEND

- PAVED RUNWAY AREAS
- URBAN/ORNAMENTAL LANDSCAPES
- DISTURBED AREAS
- BEACH
- CALIFORNIA LEAST TERN SANCTUARY
- OPEN WATER
- BRACKISH POOLS
- ESTUARINE INTERTIDAL EMERGENT WETLANDS
- NON-NATIVE GRASSLAND
- RUDERAL UPLAND VEGETATION
- 17 INSTALLATION RESTORATION SITE
- RIP RAP AREA

NOTE: BASED ON LITERATURE SOURCES AND SITE RECONNAISSANCE OBSERVATIONS IN 1995 AND 1997.

N

600 0 600 1200

SCALE: 1" = 1200'

FIGURE 2-17
ECOLOGICAL HABITAT MAP
ALAMEDA POINT
ALAMEDA, CALIFORNIA

05/13/9 /data3/alameda/arnls/alahab2.aml alahab2.map bobf 08/17/98

Tetra Tech EM Inc.

OAKLAND INNER HARBOR

WESTERN BAYSIDE

WEST BEACH LANDFILL WETLAND

SAN FRANCISCO BAY

SOUTH SHORE

RUNWAY AREA WETLAND

SEAPLANE LAGOON

BREAKWATER BEACH

LEGEND

- NAVAL AIR STATION ALAMEDA BOUNDARY
- ALAMEDA HOUSING
- LIGHT INDUSTRIAL OPERABLE UNIT
- NORTHWEST LANDFILL OPERABLE UNIT
- WEST BEACH LANDFILL OPERABLE UNIT
- CENTRAL INDUSTRIAL OPERABLE UNIT
- EASTERN INDUSTRIAL OPERABLE UNIT
- SOUTHEASTERN INDUSTRIAL OPERABLE UNIT
- HARBORSIDE OPERABLE UNIT
- OFFSHORE OPERABLE UNIT
- NORTHWEST TERRITORIES
- WILDLIFE REFUGE
- CIVIC CORE
- MARINA DISTRICT
- NORTH WATERFRONT
- INNER HARBOR
- MAIN STREET NEIGHBORHOOD
- HOUSING OPPORTUNITIES

N

700 0 700 1400

SCALE: 1" = 1400'

FIGURE 2-18
REUSE PLAN MAP
ALAMEDA POINT
ALAMEDA, CALIFORNIA

/data3/alameda/outir/reuse3.aml reuse3.map Bob

05/13/9

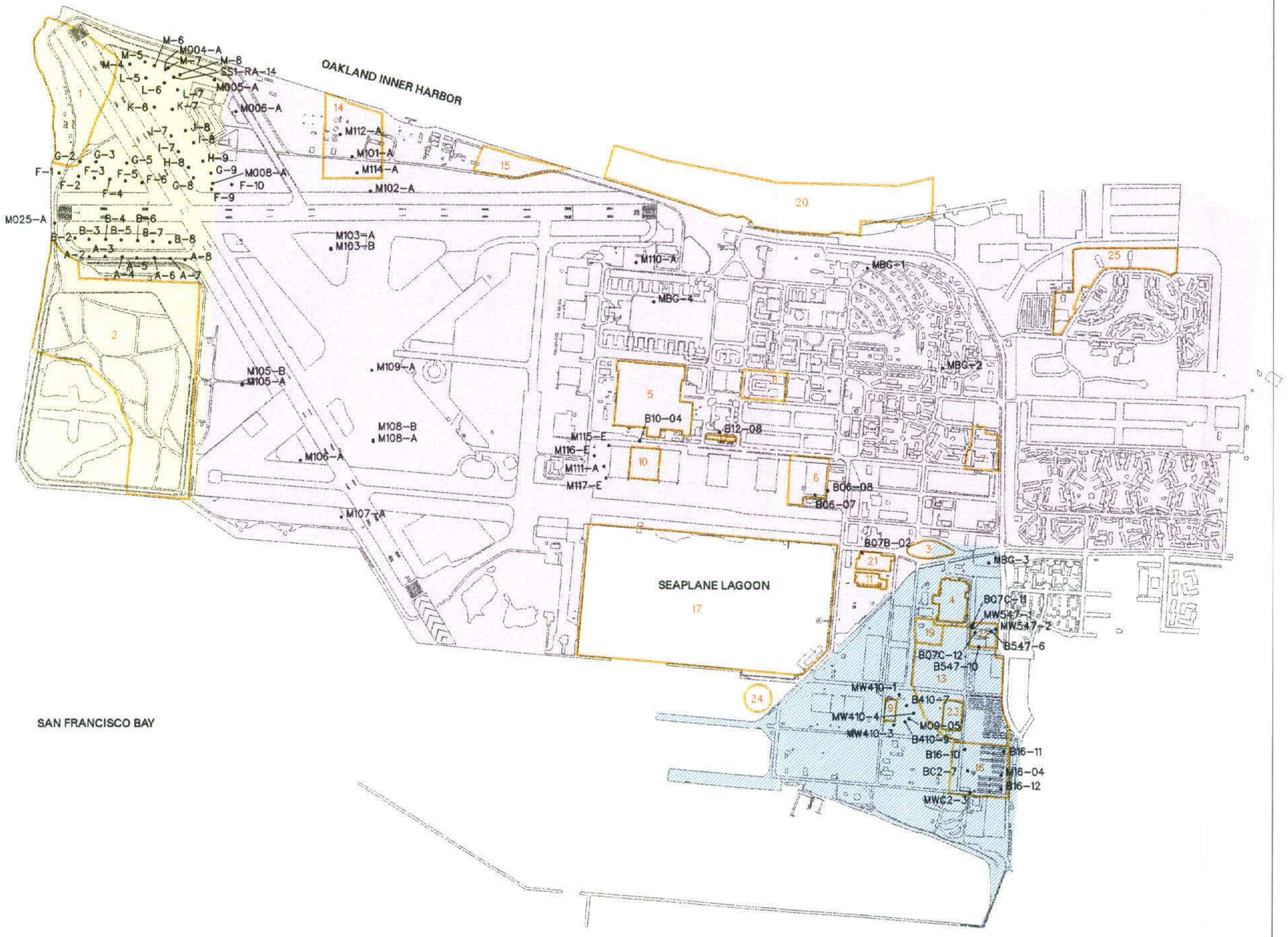


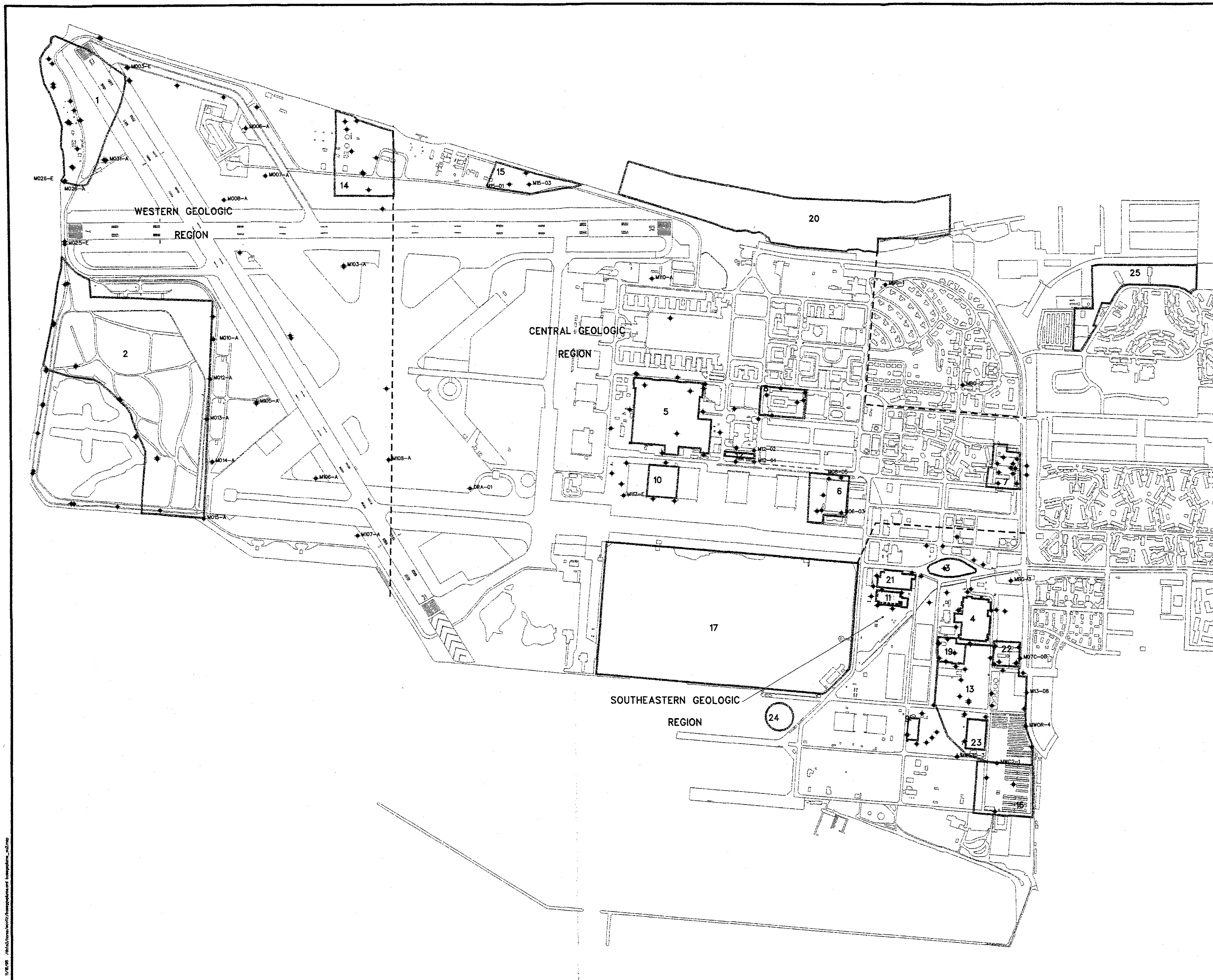
FIGURE 2-19
BACKGROUND
SOIL SAMPLE LOCATIONS

ALAMEDA POINT
ALAMEDA, CALIFORNIA

/data3/home/fraserr/arnie/back10.arnl /data3/home/fraserr/arnie/back10c.map /data3/home/arn

05/13/9

o/bookplot raiotella FSR



LEGEND

- MONITORING WELL USED FOR BACKGROUND
- MONITORING WELL FIRST WATER BEARING ZONE
- 8 — INSTALLATION RESTORATION SITE
- GEOLOGIC REGION BOUNDARY

250 0 250 500
SCALE: 1" = 500'

FIGURE 2-20
BACKGROUND MONITORING WELL LOCATION MAP
FIRST WATER-BEARING ZONE
ALAMEDA POINT
ALAMEDA, CALIFORNIA

OAKLAND INNER HARBOR

SAN FRANCISCO BAY

SAN FRANCISCO BAY

17 SEAPLANE LAGOON

1 2 4 5 6 8 9 10 11 13 14 15 19 20 22 23 24 25

LEGEND

- SEWER SYSTEM CATCH BASIN LOCATION
- SEWER SYSTEM MANHOLE LOCATION
- OUTFALL LOCATION
- ROOF DRAINS IDENTIFIED DURING CLEANING ACTIVITIES IN 1997, BUT NOT CLEANED DUE TO INACCESSIBILITY
- SEWER SYSTEM LINE CLEANED IN 1997
- SEWER SYSTEM LINE CLEANED AND INSPECTED IN 1991, NOT CLEANED IN 1997
- SEWER SYSTEM LINE REPLACED WITH PVC 1991, NOT CLEANED IN 1997
- SEWER SYSTEM LINE IN POOR CONDITION, NOT CLEANED IN 1991 OR IN 1997
- SEWER SYSTEM LINE CLEANED AND INSPECTED IN 1991, LINE FOUND TO BE IN POOR CONDITION, NOT CLEANED IN 1997
- SEWER SYSTEM LINE WHICH WAS SUPPOSED TO BE CLEANED, BUT COULD NOT BE CLEANED IN 1997, DUE TO INACCESSIBILITY.
- RADIATION CONTAMINATED, NOT CLEANED IN 1997
- 2 IR SITE
- GREEN OUTFALL INFORMATION, LINE SIZE AND LINE MATERIAL INFORMATION

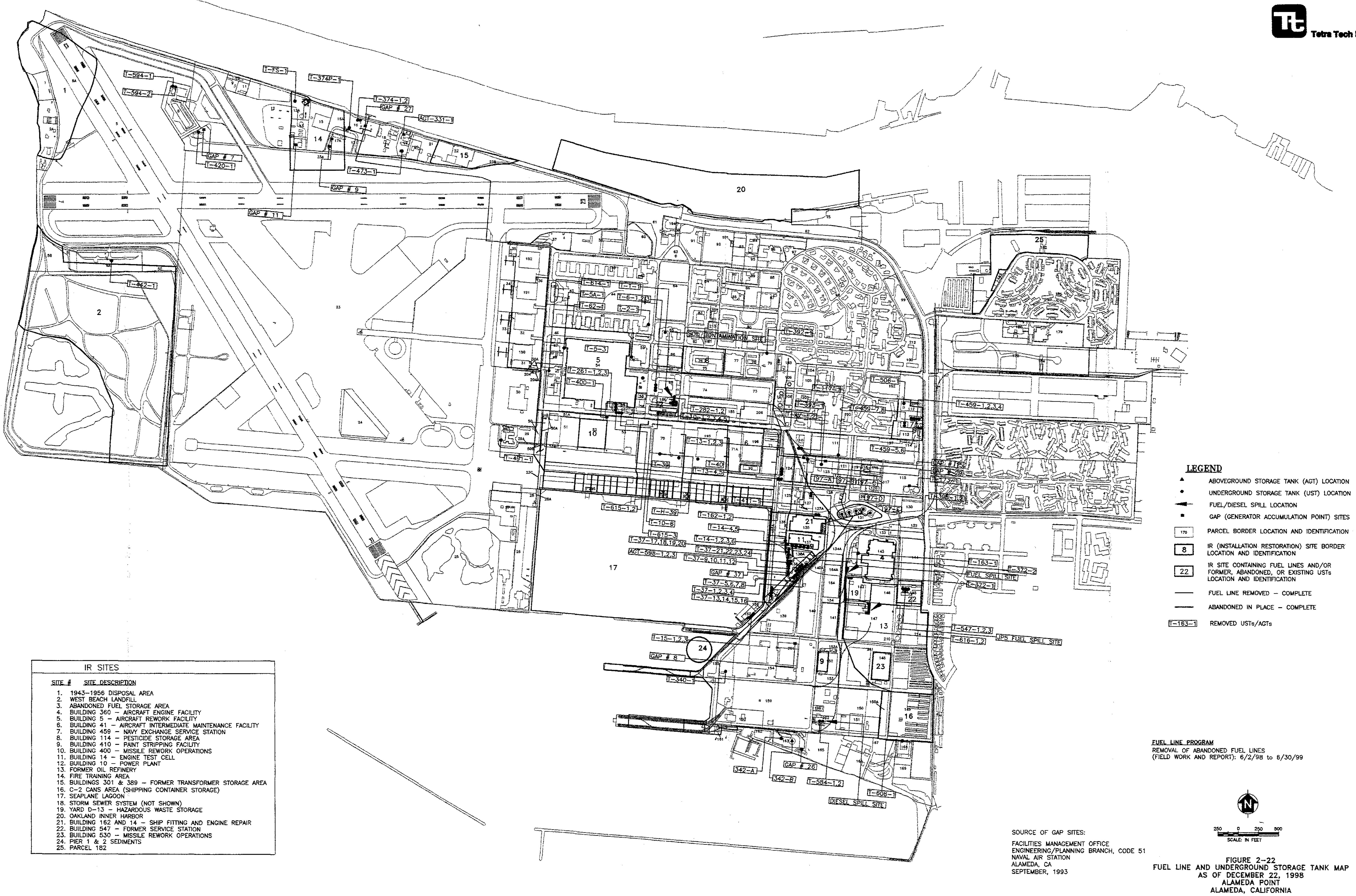
AC	ASBESTOS CEMENT
C	CONCRETE
CI	CAST IRON
CMP	CORRUGATED METAL PIPE
DI	DUCTILE IRON
PVC	POLYVINYL CHLORIDE
RC	REINFORCED CONCRETE
PIC	PAVED INVERT CORRUGATED IRON PIPE
RCP	REINFORCED CONCRETE PIPE
VC	VITRIFIED CLAY

N

250 0 250 500
SCALE: IN FEET

FIGURE 2-21
SITE 18
STORM SEWER SYSTEM
ALAMEDA POINT
ALAMEDA, CALIFORNIA

Tetra Tech EM Inc.



LEGEND

- ▲ ABOVEGROUND STORAGE TANK (AGT) LOCATION
- ● UNDERGROUND STORAGE TANK (UST) LOCATION
- ◄— FUEL/DIESEL SPILL LOCATION
- ■ GAP (GENERATOR ACCUMULATION POINT) SITES
- [179] PARCEL BORDER LOCATION AND IDENTIFICATION
- [8] IR (INSTALLATION RESTORATION) SITE BORDER LOCATION AND IDENTIFICATION
- [22] IR SITE CONTAINING FUEL LINES AND/OR FORMER, ABANDONED, OR EXISTING USTs LOCATION AND IDENTIFICATION
- —— FUEL LINE REMOVED – COMPLETE
- —— ABANDONED IN PLACE – COMPLETE
- [T-163-1] REMOVED USTs/AGTs

IR SITES

SITE #	SITE DESCRIPTION
1.	1943–1956 DISPOSAL AREA
2.	WEST BEACH LANDFILL
3.	ABANDONED FUEL STORAGE AREA
4.	BUILDING 360 – AIRCRAFT ENGINE FACILITY
5.	BUILDING 5 – AIRCRAFT REWORK FACILITY
6.	BUILDING 41 – AIRCRAFT INTERMEDIATE MAINTENANCE FACILITY
7.	BUILDING 459 – NAVY EXCHANGE SERVICE STATION
8.	BUILDING 114 – PESTICIDE STORAGE AREA
9.	BUILDING 410 – PAINT STRIPPING FACILITY
10.	BUILDING 400 – MISSILE REWORK OPERATIONS
11.	BUILDING 14 – ENGINE TEST CELL
12.	BUILDING 10 – POWER PLANT
13.	FORMER OIL REFINERY
14.	FIRE TRAINING AREA
15.	BUILDINGS 301 & 389 – FORMER TRANSFORMER STORAGE AREA
16.	C-2 CANS AREA (SHIPPING CONTAINER STORAGE)
17.	SEAPLANE LAGOON
18.	STORM SEWER SYSTEM (NOT SHOWN)
19.	YARD D-13 – HAZARDOUS WASTE STORAGE
20.	OAKLAND INNER HARBOR
21.	BUILDING 162 AND 14 – SHIP FITTING AND ENGINE REPAIR
22.	BUILDING 547 – FORMER SERVICE STATION
23.	BUILDING 530 – MISSILE REWORK OPERATIONS
24.	PIER 1 & 2 SEDIMENTS
25.	PARCEL 182

FUEL LINE PROGRAM
REMOVAL OF ABANDONED FUEL LINES
(FIELD WORK AND REPORT): 6/2/98 to 6/30/99

SOURCE OF GAP SITES:
FACILITIES MANAGEMENT OFFICE
ENGINEERING/PLANNING BRANCH, CODE 51
NAVAL AIR STATION
ALAMEDA, CA
SEPTEMBER, 1993

250 0 250 500
SCALE: IN FEET

FIGURE 2-22
FUEL LINE AND UNDERGROUND STORAGE TANK MAP
AS OF DECEMBER 22, 1998
ALAMEDA POINT
ALAMEDA, CALIFORNIA

CHAPTER 3
DATA QUALITY OBJECTIVES AND DATA APPLICATION

DQOs are qualitative and quantitative statements developed by data users to specify the quality of data needed from a particular data collection activity to support specific decisions or regulatory actions. The DQOs for the RI at Alameda Point were based on EPA guidelines in "Data Quality Objectives for Remedial Response Activities Development Process" (EPA 1987a), "Data Quality Objectives Process for Superfund Interim Final Guidance" (EPA 1993), and "Guidance for the Data Quality Objectives Process" (EPA 1994a).

DQOs for the OU-2 RI activities are described in Section 3.1. Section 3.1 also discusses the COC selection process based on the DQOs developed for this investigation. Section 3.2 summarizes data validation methods and data quality issues for the RI activities. Section 3.3 describes the use of the RI data in risk assessments and figure preparations. Specific investigative techniques and the various types of samples collected during the RI activities conducted at Alameda Point between 1990 and 1998 are described in Appendix C.

3.1 DATA QUALITY OBJECTIVES AND COC SELECTION PROCESS

The DQO process is used to determine the specific type, quality, and quantity of data to be collected during a project and to clearly define the use of the data. The following subsections describe how each of the seven steps required for the DQO process was addressed during the RI of OU-2 at Alameda Point.

3.1.1 Step 1- State the Problem

The problem to be addressed by the remedial investigation was to identify soil and groundwater contamination within OU-2 sites that would pose a significant risk to human health or the environment. This contamination would be evaluated further in an FS for possible remedial or removal actions. The primary members of the decision making team included members of the BCT, consisting of the Navy, DTSC, and EPA. Additionally, the Alameda Point reuse authority and the community are involved in the process.

3.1.2 Step 2- Identify the Decisions

The study questions that were involved in this remedial investigation were:

- What chemicals are of potential concern in the soil and groundwater at OU-2?
- What are the background concentrations of each chemical of potential concern (COPC)?
- How are the COPCs distributed in soil and groundwater at the site?
- Which COPCs are COCs for human health?
- Which COPCs are COCs for ecological resources?
- Which COCs need to be evaluated under the OU-2 FS?

The study questions above were formulated to determine whether or not any portions of the soil and/or groundwater within OU-2 at the former NAS Alameda should be evaluated in a FS for possible remedial or removal actions. Thus, any soil or groundwater that does not contain one or more COCs for human health or ecological resources, should not be evaluated in the FS for OU-2. Alternatively, soil or groundwater that contain one or more COCs for human health or ecological resources, should be evaluated in the FS for OU-2. In determining whether to include or exclude soil or groundwater from the FS, the planning team decided to use extremely conservative assumptions in answering each of the study questions above. The rationale for such conservatism was that (1) minimum time would be needed to complete the RI (because there would be less disagreement over questionable sites), thus allowing earlier planning for disposal of property found not to contain COCs, and (2) maximum flexibility would be maintained in determining future uses of the properties.

3.1.3 Step 3- Identify Inputs to the Decision

Validated chemical and biochemical data for groundwater and soil and lithologic data for soil were critical to addressing all of the principal study questions listed above. Concentrations of analytes within all of the major chemical groupings, including TPH, volatile organic compounds (VOC), SVOCs, dioxins/furans, pesticides, metals, and PCBs were used to adequately define the extent of the COPCs in groundwater and soil. In addition, parameters, such as soil density, porosity, and permeability, were analyzed as part of the lithologic assessment of OU-2. Lithologic data collected also will be used during the FS for engineering design parameters.

Also critical to the decision were the methods for determining significant differences between background concentrations and site-specific concentrations of various COPCs. In addition, the availability of standard methods for evaluating and quantifying human and ecological risks posed by each COPC was critical for addressing these study questions.

3.1.4 Step 4- Define the Study Boundaries

Numerous soil and groundwater samples were taken between 1990 and 1998 from OU-2 sites as a part of the RI activities. Each of the OU-2 areas (central, eastern, and southeastern) consist of IR sites located in close proximity to each other. Due to the close proximity of the sites within each area, the BCT decided to analyze groundwater data for sites within each area as a single data set. However, soil analysis was conducted individually for each site. Sampling locations were selected based on detailed histories of activities and potential sources of contamination for each site. Additionally, results of investigations conducted prior to the RI activities, and data from existing monitoring wells were used to select RI soil and groundwater sampling locations.

Although TPH was investigated as part of the OU-2 RI, petroleum contamination in areas determined to be contaminated exclusively with TPH is being addressed under the state's petroleum program. Therefore, OU-2 sites contaminated exclusively with petroleum constituents were not recommended for further action under the OU-2 FS; rather, such areas would be addressed under the state's petroleum program.

3.1.5 Step 5- Develop a Decision Rule

Separate decision rules were developed for each of the study questions that were listed in Section 3.1.2. These decision rules are summarized in the following paragraphs.

What chemicals are of potential concern in the soil and groundwater at OU-2? The soils and groundwater in each OU-2 area were analyzed for an exhaustive list of chemicals. Any chemical that was not detected at a given frequency, was detected consistently below one tenth of its PRG, is an essential nutrient, or was statistically equivalent to background concentrations was excluded as a COPC. See Section 5.1 and Appendix B of this report for a thorough description of criteria for selection of COPCs.

What are the background concentrations of each chemical of potential concern COPC? Specific criteria were developed to locate and measure concentrations of chemical constituents in areas of the installation that were considered to be representative of background levels. See Section 5.1 and Appendix B of this report for a thorough description of criteria for determining background concentrations of COPCs.

How are the COPCs distributed in soil and groundwater at the site? The concentrations of all COPCs were determined by implementing data collection and verification described in the quality assurance project plans prepared for all sampling and analytical activities conducted during this RI. These data were analyzed by multi-disciplined environmental staff to determine the distribution of these COPCs within soil and groundwater. The concentration of each COPC soil at each site was determined at various depth intervals.

Which COPCs are COCs for human health? A human health COPC was considered a human health COC if its concentration at a given site (stated as the upper 95 percent confidence level for all the samples) represented an excess cancer risk of one in one million for carcinogens, or a hazard index of 1 for non-carcinogens. Assumptions and procedures used in the human health risk assessments are presented in Chapter 5 of this report.

Which COPCs are COCs for ecological resources? An ecological COPC was considered an ecological COC if its concentration at a given site (stated as the upper 95 percent confidence level for all the samples) exceeded a hazard quotient of 1 for one or more specific endangered species of plants or animals that are endemic to the installation. Assumptions and procedures used in the ecological assessments are presented in Chapter 5 of this report.

Which COCs are recommended for evaluation under the OU-2 FS? Human health and ecological COCs were evaluated against risk management considerations prior to referring them to the OU-2 FS. The risk management considerations used in this evaluation were:

- A comparison of risk posed by chemical concentrations detected at the site with risk posed by background or ambient concentrations of the same chemicals at Alameda Point
- Distribution and frequency of detection of the COCs at the site and assessment of potential sources

- Fate and transport modeling results
- Potential for the use of groundwater as a source of drinking water at Alameda Point

3.1.6 Step 6- Specify Limits on Decision Errors

As stated in Section 3.1.2, the decisions that were constructed to determine which sites would be evaluated in the FS for OU-2 were extremely conservative. Thus these decisions are heavily weighted in favor of selection of sites which may not pose significant risks to human health or the environment for further evaluation under the FS. During the FS, the various sites within OU-2 will be evaluated under more realistic assumptions to determine which of these sites should receive remedial actions.

3.1.7 Step 7- Optimize the Sampling Design

All sampling designs that were used to collect the data used in this RI, were optimized within the constraints of the above-mentioned DQO that were developed for this RI.

3.2 DATA QUALITY DOCUMENTATION AND DATA VALIDATION

This section provides data quality documentation for the RI activities and a description of the data validation process used to evaluate the data for usability. Specifically, Section 3.2.1 discusses the data quality levels for RI activities (based on the Navy's data quality criteria), Section 3.2.2 discusses the data quality documentation prepared for the RI, and Section 3.2.3 discusses the data validation performed for the OU-2 data. Section 3.2.3 also discusses the critical parameters used to evaluate data quality during data validation and the data validation process and whether DQOs for the Alameda Point RI were met.

RI activities were conducted at Alameda Point in a phased approach and chemical data sets for each phase were obtained from the laboratories. The RI activities were conducted in accordance with work plans prepared for the Alameda Point IR program (Canonie 1990; PRC and Tetra Tech, Inc. 1992; PRC and MW 1993; PRC 1996b, 1996c). The various phases of RI activities as indicated on Table 1-1 were not conducted on a site-specific basis. Therefore, quality control summary reports (QCSR) for Alameda Point RI activities were prepared for various phases of the investigations on a non-site-specific basis.

3.2.1 Data Quality Levels

The DQOs developed for the RI activities at Alameda Point dictated whether analytical data generated would be of either screening or definitive quality. Each of these categories is defined by quality assurance and quality control (QA/QC) procedures specific to each field or laboratory analytical method used. In support of the DQOs, both screening data and definitive data were generated using a wide range of field and laboratory methodologies.

The field screening and definitive data generated for use in the Alameda Point RI are distributed among Naval Energy and Environmental Support Activity (NEESA) quality control (QC) Levels A, B, C, D, and E, and correlate directly with EPA Levels 1, 2, 3, 4, and 5, respectively (Navy 1990a). Sample analyses performed in the field using criteria specified for NEESA QC Levels A and B generated qualitative and semi-quantitative field screening data. Sample analyses performed in a fixed laboratory using criteria specified for NEESA levels C, D, and E generated definitive data. A brief description of each QC level has been excerpted from the NEESA guidance document (Navy 1990a) and is presented below.

NEESA Level A Field Analytical Data:

Level A data are [field] data that are non quantitative and are used as indicator parameters. Level A corresponds directly with EPA Level 1. Examples of Level A data include data generated in the field using volatile organic analyzers; immuno-assay field test kits; or water quality meters such as pH, temperature, conductivity, and turbidity meters.

NEESA Level B Field Analytical Data:

Level B data are [field] data that are quantified. Level B corresponds directly with EPA Level 2. Examples of Level B data include data generated in the field using field-portable or mobile laboratory gas chromatographs, spectrophotometers, or x-ray fluorescence detectors.

NEESA Level C Laboratory QA:

Level C QC includes review and approval of the laboratory quality assurance plan (LQAP) and the field quality assurance (QA) plan.

EPA-accepted methods, such as those in SW-846, the National Pollutant Discharge Elimination System (NPDES), and the Contract Laboratory Program (CLP) Statement of Work (SOW) are utilized under Level C.

Minimum QC requirements are specified and reported, however, the level of documentation, such as raw data reports, are not stringent as for Level D. Level C data may be used for risk

assessment, site characterization, evaluation of alternatives, engineering design, and monitoring during implementation.

NEESA Level D Laboratory QA:

Level D QC is to be used when comprehensive data quality documentation is required. Level D QC includes review and approval of the LQAP and the project work plan, including the sampling and analysis plan, and the QA plan.

For Level D, CLP methods and full data package deliverables are required for analyses covered by these methods. Methods not included in the CLP will be evaluated to Level D by including appropriate QC samples (same as Level C) and submitting all raw sample and calibration data. Because all raw sample data, calibration, and QC documentation is presented, the reviewer can fully assess data quality.

This data may be used for risk assessment, site characterization, evaluation of alternatives, engineering design, and monitoring implementation.

NEESA Level E Laboratory QA:

Level E QC is used for RI analysis of nonstandard sample matrices, such as air, biota, and pure waste. It may also be employed for nonstandard methods, such as those used for explosives. Specific QC requirements must be clearly and completely identified in the project work plan when Level E is employed.

Level E QC includes review and approval of the LQAP and the project work plan, including the sampling and analysis plan, and the QA plan. Because few methods are available for nonstandard matrices, the methods to be used for Level E analyses must be submitted for review and approval prior to the initiation of work.

This data may be used for risk assessment, site characterization, evaluation of alternatives, engineering design, and monitoring implementation (Navy 1990a).

As stated above, data generated for the Alameda Point RI are distributed among NEESA QC Levels A, B, C, D, and E. Level A and B data were generated in the field and were used (1) for health and safety monitoring, (2) as indicator parameters for groundwater monitoring sampling, (3) as guidance for field investigations, and (4) as guidance for removal actions. As specified in the NEESA guidance document, only Level C, D, and E quality data, or definitive data, are usable for the purposes of risk assessment, site characterization, evaluation of alternatives, engineering design, and monitoring implementation (Navy 1990a). For this reason, Level A and B data are not included in the Alameda Point chemical database and consequently are not included in the OU-2 data set. Therefore, this report's discussion of data quality for the Alameda Point RI is limited to the definitive data generated for the RI.

3.2.2 Data Quality Documentation

For early RI sampling activities (not including ecological assessment sampling activities), the quality of definitive data generated by Canonie is equivalent to NEESA QC Level C as described in the quality assurance project plan (QAPP) and QA/QC plan, which makes up Volume 3 of the RI work plan (Canonie 1990), with two exceptions. The two exceptions are that CLP methods were not used for gas chromatogramphy/mass spectrometry (GC/MS) analyses for VOCs and SVOCs. The sampling plan, which is Volume 1 of the RI work plan (Canonie 1990), specifies EPA 600 methods (EPA 1979) and EPA SW-846 methods (EPA 1986) for analyses of organic compounds by GC/MS. Data needs for the early RI sampling activities are identified in the sampling plan (Canonie 1990) and are consistent with the EPA guidance titled "Data Needs for Selecting Remedial Action Technologies" (EPA 1987b). For follow-on RI sampling activities, the quality of the definitive data generated is equivalent to NEESA QC Level D as described in the QAPP revision, which is Chapter 3 of the NAS Alameda RI work plan addendum (PRC and MW 1993).

As specified in the QAPP and QAPP addendum prepared as part of the field investigation work plans, the quality of the definitive data generated during subsequent sampling events, such as the events listed below, are equivalent to NEESA QC Level D.

(1) the tidal influence study and additional work at Sites 4 and 5 (PRC and JMM 1993b);
(2) the IR Sites 4 and 5 solvent plume investigation and IR Site 14 sump investigation (TtEMI 1997a);
(3) 1997 and 1998 groundwater monitoring (PRC and U&A 1997); and
(4) the IR Site 14 solvent plume and IR Site 25 investigations (TtEMI 1998c)

The quality of the groundwater VOC field data generated by GC/MS for the IR Sites 4 and 5 solvent plume investigation (PRC 1997) and the IR Site 14 solvent plume investigation (TtEMI 1998c) is equivalent to NEESA QC Level B. Therefore these data are not included in the OU-2 data set; however, at least 10 percent of the groundwater samples were sent off site for definitive confirmation analysis.

The QAPPs used for the Alameda Point OU-2 RI sampling activities were prepared according to the following five EPA guidance documents.

(1) "Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans" (EPA 1980);

(2) "Data Quality Objectives for Remedial Response Activities Development Process" (EPA 1987a),

(3) "U.S. EPA Region IX Guidance for Preparing Quality Assurance Project Plans for Superfund Remedial Projects" (EPA 1989b),

(4) "Guidance for the Data Quality Objectives Process" (EPA 1994a), and (5) "EPA Requirements for Quality Assurance Project Plans for Environmental Data Operations" (EPA 1994b).

For initial ecological assessment sampling activities performed at Alameda Point, samples were collected and definitive data were generated based on the QAPP presented as Appendix A of the "Work Plan for an Ecological Assessment" (PRC and Tetra Tech, Inc. 1992). The quality of the initial ecological data is equivalent to NEESA QC Levels C and E. For follow-on ecological assessment sampling activities, samples were collected and definitive data were generated based on the QAPP for the characterization of the Seaplane Lagoon (PRC 1996c) and the QAPP addendum for the follow-on ecological assessment (PRC 1996d). The quality of the follow-on ecological data is equivalent to NEESA QC Levels D and E.

The QAPPs used for the ecological sampling activities in support of the Alameda Point RI were prepared in accordance with the following four EPA guidance documents.

(1) "Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans" (EPA 1980);

(2) "Data Quality Objectives for Remedial Response Activities Development Process" (EPA 1987a);

(3) "Guidance for the Data Quality Objectives Process" (EPA 1994a); and

(4) "EPA Requirements for Quality Assurance Project Plans for Environmental Data Operations" (EPA 1994c).

3.2.3 Data Validation

The methods and procedures used to analyze RI samples collected at Alameda Point were chosen such that analytical data of acceptable quality and quantity would be generated in support of the DQOs described in Section 3.1. For early RI activities performed by Canonie at Alameda Point, data were generated using methods specified in the RI work plan (Canonie 1990); however, most of the data were generated under the QAPP revision that constitutes Chapter 3 of the NAS Alameda RI work plan addendum (PRC and MW 1993).

The acceptability of analytical data (the determination of the quality of the data as it pertains to the usability of the data for purposes identified in the DQOs) is evaluated using the critical indicator parameters of precision, accuracy, representativeness, completeness, and comparability (PARCC). The acceptability of analytical data is determined through the process of data validation. Data validation consists of a detailed review of the raw data to determine their quality. To perform data validation, the laboratory generating the data must provide the data user with full data packages documenting all details of the analyses performed. Although the Canonie data for OU-2 were generated by certified laboratories using approved EPA methods, the documentation required for these data did not include data packages; therefore, no validation on these data was performed and no evaluation of the data quality can be made. However, based on the NEESA definitions of data quality levels, the Canonie data are considered to be Level C quality and may be used for RI and risk assessment purposes; therefore, the Canonie data and the initial ecological data have been used in the Alameda Point RI. These data make up less than 10 percent of the overall data set.

For the data gathered during the RI Phase 2B and 3 investigations and the follow-on RI sampling activities, data validation was performed based on the PARCC parameters. Detailed reports on the data validation process can be found in the following documents.

(1) "Data Summary Report for RI Phases 2B and 3 QCSR" (PRC and JMM 1992a);

(2) "Draft QCSR for Follow-on RI Activities for Soil, Sediment, and HydroPunch® Samples" (PRC 1996b);

(3) "Draft QCSR for Follow-on RI Activities for Four Quarters of Groundwater Sampling" (TtEMI 1998d);

(4) "QCSR for Follow-on Ecological Assessment and Seaplane Lagoon" (PRC 1997b); and (5) "QCSR for 1997/1998 Quarterly Groundwater Monitoring" (TtEMI 1999c).

The following sections describe the PARCC parameters and how they were evaluated with respect to data quality and the data validation process.

3.2.3.1 Critical Parameters

In the data validation process, the data collected for OU-2 were evaluated for acceptable quality and quantity based on the PARCC critical indicator parameters. This section discusses how these critical indicator parameters were evaluated with respect to data quality.

Precision. Precision was measured by evaluating field duplicate samples, matrix spike duplicate samples, and matrix duplicate pairs. Precision was expressed as the relative percent difference (RPD) of a pair. Precision objectives for each analytical methodology used are stated in the specific QAPP that the data were generated under. During the process of data validation, all field duplicate samples, matrix spike duplicate samples, and matrix duplicate pairs were evaluated for compliance with the acceptance criteria for precision (expressed as RPDs) for each applicable analytical methodology. These RPD evaluations are documented in the individual QCSRs prepared for each phase of the Alameda Point RI (PRC and JMM 1992c; PRC 1996b; TtEMI 1998d).

Accuracy. Accuracy was measured by evaluating matrix spike samples, laboratory control samples, surrogate recoveries (for organic analyses), and radiometric and gravimetric yields (for radiometric analyses). Accuracy was expressed as percent recovery. Accuracy objectives for each analytical methodology used are stated in the specific QAPP under which the data were generated. Through the process of data validation, all matrix spike samples, laboratory control samples, surrogate recoveries, and radiometric and gravimetric yields were evaluated for compliance with the acceptance criteria for accuracy for each applicable analytical methodology. The evaluations of percent recovery are documented in the individual QCSRs prepared for each phase of the Alameda Point RI (PRC and JMM 1992c; PRC 1996b; TtEMI 1998d).

Representativeness. Sample results were evaluated for representativeness by examining items related to the collection of samples such as the chain-of-custody documentation that includes labeling of samples, sample collection dates, and the condition of the samples upon their receipt at the laboratory. Laboratory procedures and performance were also examined, including reporting of anomalies reported by the laboratory either upon receipt of the samples at the laboratory or during the analytical process, holding times for samples prior to their analysis, calibration of laboratory instruments, adherence to analytical methods, quantitation limits used for samples, and the completeness of the data package documentation. Any anomalies reported by the field sampling technicians or laboratories that affected the representativeness of the samples are documented in the individual QCSRs prepared for each phase of the Alameda Point RI (PRC and JMM 1992c; PRC 1996b; TtEMI 1998d).

Completeness. Completeness was defined as the percentage of measurements judged valid. The validity of sample results was determined through the data validation process. All sample results that were rejected, and any missing analyses, were considered incomplete. Data qualified as estimated were

considered valid and usable. Any anomalies reported by the field sampling technicians or laboratories that affected the representativeness of the samples are documented in the individual QCSRs prepared for each phase of the Alameda Point RI (PRC and JMM 1992c; PRC 1996b; TtEMI 1998d).
The completeness goal for the Alameda Point RI analytical data (as documented in the QAPPs) is 90 percent. Completeness was measured as the number of complete, valid sample results divided by the total number of sample results. To calculate the total number of sample analyses, each compound or analyte for each methodology was multiplied by the total number of samples analyzed. The completeness goal of 90 percent was met as documented in the individual QCSRs prepared for each phase of the Alameda Point RI (PRC and JMM 1992c; PRC 1996b; TtEMI 1998d).

Comparability. Comparability of data is a qualitative parameter that expresses the confidence with which one data set may be compared to another. Comparability of data is achieved using standard methods of sampling and analysis, standard quantitation limits, and standardized data validation procedures. Soil sample results generated using CLP methods are reported in dry-weight units (results are adjusted for moisture content). Quantitation limits within a method varied slightly from sample to sample due to the adjustments for moisture content; however, this does not affect data quality. Soil sample results generated using SW-846 methods were reported on a wet-weight basis, unless otherwise specified in the QAPP.

Elevated reporting limits were assessed during the data validation process to determine whether a justifiable reason existed for the raised limits. Reporting limits were raised in cases where sample extracts were diluted and analyzed or a smaller aliquot of an original sample was analyzed because of high concentrations of target or interfering compounds. In most cases, the elevated reporting limits were considered acceptable and did not affect data quality.

3.2.3.2 Data Validation Process

Analytical data generated for RI Phases 2B and 3 and the follow-on RI activities were validated in accordance with the following documents.

(1) "National Functional Guidelines for Organic Data Review" (EPA 1990a);

(2) "Draft National Functional Guidelines for Organics for the Pesticide Fraction" (EPA 1991b); and

(3) "Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Analyses" (EPA 1988a).

All analytical results reported for each data set (usually consisting of 20 or fewer samples) that were analyzed for many constituents by various methods were validated based on the criteria specified in these functional guidelines. Table 3-1 summarizes the analytical methods used for OU-2 samples. The data validation parameters reviewed for CLP inorganics, CLP organics, and non-CLP organics and inorganics are presented in Table 3-2.

Once the data were validated, validation qualifiers were applied to the analytical results as appropriate. Data validation qualifiers are alphabetic characters assigned to reported values that correspond to definitions specified in the functional guidelines. Functional guideline data validation qualifiers and their definitions are listed in Table 3-3.

The laboratories submitted analytical reports containing laboratory qualifiers that are defined by either the EPA CLP SOW or the laboratory standard operating procedures (SOP). The CLP- or laboratory-defined qualifiers identified such items as nondetected values, values below the contract-required quantitation limit (CRQL) (considered estimated values), and values associated with problems during the analysis. During data validation, these CLP- or laboratory-defined data qualifiers were evaluated for appropriateness and were replaced as necessary with the appropriate functional guideline data validation qualifiers. The validated data, including appropriate qualifiers, are stored electronically in the Alameda Point RI chemical database.

In addition to analytical results with associated qualifiers, the chemical database includes a provision for assigning validation comment codes. A comment code is used to explain an assigned qualifier. The letters "a" through "h" were established for the comment codes and are used to reference different QC issues that may have impacted the analytical results. The definitions for these comment codes are provided in Table 3-3.

Based on the data validation process documented in the individual QCSRs prepared for each phase of the Alameda Point RI (PRC and JMM 1992c; PRC 1996b; TtEMI 1998d), the validated analytical results generated for the OU-2 IR sites provide:

(1) QC Level D and E data as defined by NEESA guidance (Navy 1990a); and

(2) modified Level 4 data as defined by EPA guidance "Data Quality Objectives for Remedial Response Activities Development Process" (EPA 1987a) ("modified" that full validation was performed on only 10 percent of the data). NEESA QC Level D and E and EPA Level 4 data are suitable for site characterization and risk assessment purposes, thus supporting the DQOs of the RI.

3.3 DATA USE FOR RISK ASSESSMENTS AND FIGURE PREPARATIONS

Chemical data collected during the RI activities (described in Section 2.7.2) were used in the preparation of this RI report. This section provides brief descriptions on the use of chemical data in the risk assessment and preparation of figures for soil and groundwater.

3.3.1 Soil Data Analyses

All soil data collected during the RI activities were analyzed using off-site laboratory analysis techniques usable for risk assessments and presentation on figures. Therefore, all soil data collected were used in human health and ecological risk assessments, and soil data presentation figures.

3.3.2 Groundwater Data Analyses

Groundwater data were collected at Alameda Point from monitoring well and HydroPunch® locations. All monitoring well samples collected were analyzed at off-site laboratories. HydroPunch® samples, typically used for delineation of groundwater plumes, were analyzed using field screening analytical techniques. For confirmation purposes, 10-15 percent of the HydroPunch® samples were analyzed in off-site laboratories.

Monitoring wells were installed at Alameda Point in 1990 and 1994. Groundwater sampling at these wells was conducted during three investigation periods (1990-1991, 1994-1996, 1997-1998). However, the most complete set of monitoring well data (involving most of the wells) were collected during the 1994-1996 quarterly monitoring events. Quarterly monitoring conducted at Alameda Point during 1997-1998 involved approximately half of all monitoring wells.

The following text describes use of monitoring well and HydroPunch® data for conducting human health and ecological risk assessments, and preparation of groundwater data presentation figures, and groundwater plume maps.

Groundwater Risk Assessments. The risk assessments were conducted using only off-site laboratory data. Therefore, risk assessments were conducted using all available monitoring well data, and the small percentage (10 – 15 percent) of HydroPunch® data that were analyzed in off-site laboratories. The monitoring well data included were limited to the last four quarterly monitoring events ending in 1996, since the 1994-1996 data represent the most complete set of monitoring well data for Alameda Point.

Groundwater Data Presentation Figures. The purpose of the data presentation figures is to graphically display the distribution of chemicals evaluated in the risk assessments. Therefore, all off-site laboratory HydroPunch® data and four-quarter average of concentrations recorded at each monitoring well during the 1994-1996 monitoring events were displayed on these figures. Additionally, monitoring well data for samples collected from selected monitoring wells in 1990-1991 and 1997-1998 are presented in time series plots for trend analysis purposes.

Groundwater Plume Maps. Plume maps for specific chemicals were prepared using the monitoring well and HydroPunch® data displayed on the figures described above. In addition to the above data, field screening HydroPunch® data were available for Site 14 and OU-2 eastern and central areas. These field screening data were collected for plume delineation purposes and were therefore used in preparing the plume maps. The plume maps indicate sample locations for all monitoring well and off-site laboratory and field-screening HydroPunch® sample locations.

TABLE 3-1
ANALYTICAL METHODS
OU-2, ALAMEDA POINT
(Page 1 of 2)

Method Manual	Analytical Method	Analyte Group or Parameter
EPA CLP [a] [b]	CLP SOW	Volatile Organic Compounds
	CLP SOW	Semivolatile Organic Compounds
	CLP SOW	Organochlorine Pesticides and PCBs
	CLP SOW	Metals and Cyanide
	CLP SOW	Percent Moisture and pH
EPA SW-846 [c]	8020	Purgeable Aromatic Hydrocarbons
	8080	Pesticides and PCBs
	8240	Volatile Organic Compounds
	8270	Semivolatile Organic Compounds
	6010, 7196A, 7060, 7471, 7740	Metals
	9010	Cyanide
	9045, 9045A	pH
	9030	Sulfide
	9040	pH
	9073	Total Recoverable Petroleum Hydrocarbons
	9081	Cation Exchange Capacity
	9060	Total Organic Carbon
	9050A	Conductivity
	9070, 9071A	Oil and Grease
	1010, 1020	Flashpoint
EPA 600 [d]	608	Pesticides and PCBs
	624	Volatile Organic Compounds
EPA 500 [e]	504	Ethylene Dibromide
MCAWW [f]	305.1, 305.2	Acidity
	335.2, 335.3	Cyanide
	325.2, 340.2, 353.1, 353.2	Anions (Chloride, Fluoride, Nitrate/Nitrite)
	310.1	Alkalinity
	351.3	Total Kjeldal Nitrogen
	160.1	Percent Solids (Filterable)
	418.1, 418.2	Total Recoverable Petroleum Hydrocarbons
	130.2	Total Hardness
	413.1, 413.2	Total Recoverable Oil and Grease
	200.7	Metals

TABLE 3-1
ANALYTICAL METHODS
OU-2, ALAMEDA POINT
(Page 2 of 2)

Method Manual	Analytical Method	Analyte Group or Parameter
MCAWW [f] (Continued)	300.0	Anions (Chloride, Fluoride, Sulfate, Nitrate, Nitrite)
	120.1	Conductivity
	150.1	pH
	405.1	Biological Oxygen Demand
	425.1	MBAs
	376.1	Sulfide
	360.1	Dissolved Oxygen
	415.1, 415.2	Total Organic Carbon
	410.1	Chemical Oxygen Demand
Standard Methods [g]	SM 5310	Total Organic Carbon
	SM 2320	Alkalinity
California LUFT Manual [h]	8015-modified	Total Extractable Petroleum Hydrocarbons
	8015-modified	Total Purgeable Petroleum Hydrocarbons
ASTM [i]	D2216	Percent Moisture
	D2974	Total Organic Carbon
	D3286	Flashpoint

Notes:

(a) Contract Laboratory Program (CLP) Statement of Work (SOW) for Inorganic Analyses (EPA 1990c)
(b) CLP SOW for Organic Analyses (EPA 1990d)
(c) Test Methods for Evaluating Solid Waste, SW-846 (EPA 1986)
(d) Test Methods for the Analysis of Industrial and Municipal Waste Water, EPA 600 (EPA 1979)
(e) Methods for the Determination of Organic Compounds in Drinking Water, EPA 500 (EPA 1990e)
(f) Methods for Chemical Analysis of Water and Wastes(MCAWW) (EPA 1983)
(g) Standard Methods for the Examination of Water and Wastewater (American Public Health Association 1992)
(h) California Leaking Underground Fuel Tank (LUFT) Manual (SWRCB 1988)
(i) American Society for Testing and Materials (ASTM 1994)

EPA U.S. Environmental Protection Agency
MBA Methylene-blue acting substance
PCB Polychlorinated biphenyl
SWRCB California State Water Resources Control Board

TABLE 3-2
DATA VALIDATION PARAMETERS
OU-2, ALAMEDA POINT
(Page 1 of 2)

CLP Inorganic Parameters [a] [b]	
*	Holding times
*	Calibrations (initial and continuing)
*	Blanks (method, instrument, and preparation blanks)
	ICP interference check sample
*	Laboratory control sample
*	Duplicate sample analysis
*	Matrix spike sample analysis
	GFAA QC
*	ICP serial dilution
	Sample result verification
*	Field duplicates
*	Overall assessment of data for an SDG
CLP Organic Parameters [a] [c]	
*	Holding times
	GC/MS tuning
*	Calibrations (initial and continuing)
*	Blanks (method, instrument, and preparation blanks)
*	Surrogate recovery
*	Matrix spike/matrix spike duplicate
*	Field duplicates
*	Internal standard performance
	Target compound identification
	Tentatively identified compounds
	System performance
	Sample result verification
*	Overall assessment of data for an SDG
Non-CLP organic and inorganic Parameters [a] [b] [c] [d]	
*	Method compliance
*	Holding times
*	Calibrations (initial and continuing)
*	Blanks (method, instrument, and preparation blanks)
*	Surrogate recovery
*	Sample duplicates, matrix spikes, matrix spike duplicates, blank spikes
*	Other laboratory QC specified by the method
*	Field duplicates
	Compound identification, quantitation, detection limits, and result verification
*	Overall assessment of data for an SDG

TABLE 3-2
DATA VALIDATION PARAMETERS
OU-2, ALAMEDA POINT
(Page 2 of 2)

Notes:

(a) All items listed are evaluated in a full validation review. Cursory review items are indicated by an asterisk (*).
(b) National Functional Guidelines for Inorganic Data Review (EPA 1994)
(c) National Functional Guidelines for Organic Data Review (EPA 1994)
(d) Data Validation Statement of Work, Comprehensive Long-Term Environmental Action Navy (CLEAN II) (PRC 1997)

CLP	Contract Laboratory Program
GC/MS	Gas chromatography/mass spectrometry
GFAA	Graphite furnace atomic absorption
ICP	Inductively coupled plasma
QC	Quality control
SDG	Sample delivery group

TABLE 3-3
DATA VALIDATION QUALIFIERS
AND DATABASE COMMENT CODES
OU-2, ALAMEDA POINT

Qualifier/Code	Description
Data Validation Qualifiers [(a) (b) (c)]	
U	Indicates that the compound was analyzed for but was not detected above the concentration listed. The value listed is the sample quantitation limit.
J	Indicates an estimated concentration. The result is considered qualitatively acceptable but quantitatively unreliable.
UJ	Indicates an estimated quantitation limit. The compound was analyzed for but was considered nondetected.
JN	Indicates the presence of an analyte that has been "tentatively identified". The associated numerical value represents the analytes approximate concentration.
R	Indicates the result is unusable (compound may or may not be present). Resampling and reanalysis are necessary for verification.
No qualifier	Indicates that the result is acceptable both qualitatively and quantitatively
Database Comment Codes	
a	Surrogate spike recovery problems
b	Blank contamination problems
c	Matrix spike recovery problems
d	Duplicate (precision) problems
e	Internal standard problems
f	Calibration problems
g	Quantification below the reporting limit
h	Other problems; refer to data validation narrative

Notes:

(a) National Functional Guidelines for Inorganic Data Review (EPA 1994)
(b) National Functional Guidelines for Organic Data Review (EPA 1994)
(c) Data Validation Statement of Work, Comprehensive Long-term Environmental Action Navy (CLEAN II) (PRC 1997)

CHAPTER 4
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

This chapter presents the applicability of ARARs at federal facilities, the development of ARARs, and identifies specific ARARs for IR sites within OU-2.

Section 121(d) of CERCLA as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA) states that remedial actions selected under Section 104 of CERCLA shall require a level or standard of control of hazardous substances that meets ARARs under federal or state environmental or facility siting laws. ARARs may include standards, criteria, limitations, or other requirements promulgated under federal or state laws. ARARs are used to determine the appropriate cleanup level for a given site, develop site-specific remedial response objectives, develop remedial action alternatives, and direct site cleanup. ARARs apply only to hazardous substances that remain on site. The transfer of hazardous substances off site must comply with all applicable federal and state laws.

In addition to ARARs, the National Oil and Hazardous Substances Contingency Plan (NCP) provides that agency advisories, criteria, or guidance may be considered ("to be considered" or "TBC") for a particular release (40 *Code of Federal Regulation* [CFR] § 300.400(g)(3)). As explained in the Preamble to the NCP, "TBCs should not be required as cleanup standards because they are, by definition, generally neither promulgated nor enforceable so they do not have the same status under CERCLA as do ARARs. TBCs may, however, be very useful in helping to determine what is protective at a site, or how to carry out certain actions or requirements" (*55 Federal Register* 8745).

4.1 APPLICABILITY OF REGULATORY REQUIREMENTS AT FEDERAL FACILITIES

Section 120 of CERCLA provides guidance for remediation of hazardous substances released from federal facilities. CERCLA requires the Navy (in addition to other branches of the federal government) to comply with CERCLA in the same manner and to the same extent as nongovernmental entities.

Under Executive Order 12580 - Superfund Implementation, the President of the United States delegated to the Secretary of Defense the responsibility for responding to releases or threats of releases of hazardous substances from facilities and vessels under the jurisdiction of the U.S. Department of Defense (DOD). Section 2701 of SARA, the Environmental Restoration Program, authorizes the Secretary of Defense to carry out a program of environmental restoration at facilities under his or her jurisdiction. DOD environmental restoration activities must be carried out in a manner consistent with Section 120 of

CERCLA. Section 120(a)(4) of CERCLA also states that federal facilities not listed on the National Priority List (NPL) will be subject to state laws concerning removal and remedial actions.

On February 26, 1999, EPA notified the State of California that EPA is considering placing Alameda Point on the NPL, but as of the date of this RI report this action has not been taken. Unless and until Alameda Point is made an NPL site, any remedial actions taken at Alameda Point will be consistent with state laws pertaining to removal and remedial actions.

4.2 DEFINITION AND DEVELOPMENT OF ARARS

An ARAR may be either "applicable" or "relevant and appropriate" but not both. The NCP defines "applicable requirements" and "relevant and appropriate" as follows:

- "Applicable requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state environmental or facility siting law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be applicable."

- "Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state environmental or facility siting law that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be relevant and appropriate."

Preliminary identification of ARARs involves considering a number of site-specific factors, including potential remedial actions, compounds at the site, physical characteristics of the site, and the site location. A requirement is applicable if it specifically addresses or regulates the hazardous substance, pollutant, contaminant, action being taken, or other circumstances at the site. To determine whether a particular requirement would be legally applicable, it is necessary to evaluate specific jurisdictional prerequisites of the statute or regulation. All pertinent jurisdictional prerequisites must be met for the requirement to be applicable. Jurisdictional prerequisites include the following:

- Who, as specified by the regulation, is subject to its authority
- The types of substances and activities listed as falling under the authority of the regulation
- The time period for which the regulation is in effect
- The types of activities that the regulation requires, limits, or prohibits

If jurisdictional prerequisites are met, the requirement is applicable. If not, the next step is to consider whether the requirement is relevant and appropriate (EPA 1988b). The basic considerations when determining whether a requirement is relevant and appropriate include evaluating whether the requirement addresses situations or problems sufficiently similar to those encountered at the CERCLA site (that is, its relevance) and whether its use is well suited to the site (that is, its appropriateness). Determining whether a requirement is relevant and appropriate is a site-specific process carried out in accordance with the factors listed in Part 400.300(g)(2) of the NCP. The determination is based on the best professional judgment of the lead agency (EPA 1988b, 1989b). Only those requirements or portions of a requirement that are determined to be both relevant and appropriate must be complied with (EPA 1988b).

Additionally, only laws and regulations that contain environmental or siting requirements can be ARARs, and only the substantive provisions of those environmental or siting requirements are considered ARARs. Thus, for example, provisions of environmental or siting requirements that are procedural or administrative in nature are not ARARs. Record-keeping, permitting, and reporting requirements are not ARARs. Waivers from meeting specific ARARs may be obtained under certain conditions defined in Section 121(d)(4) of CERCLA as amended by SARA. These conditions are as follows:

- The remedial action selected is only part of a total remedial action that will meet the ARAR when completed.
- Compliance with the ARAR will result in greater risk to human health and the environment.
- Compliance with the ARAR is technically impractical from an engineering perspective.
- The remedial action selected will attain a standard of performance equivalent to the ARAR through use of another method or approach.
- With respect to a state ARAR, the state has not consistently applied or demonstrated the intention to consistently apply the standard, requirement, criterion, or limitation in similar circumstances for other remedial actions within the state.

Several waivers may apply to a site as a whole or to specific remedial alternatives and may require further technical evaluation. A particular ARAR may be waived provided that the remedial actions selected are protective of human health and the environment. If a waiver of a particular ARAR is determined to be applicable, the waiver will be documented in a ROD, provided that the remedial actions are protective of human health and the environment.

4.3 IDENTIFICATION OF POTENTIAL ARARS

ARARs must be identified on a site-specific basis. Neither CERCLA nor the NCP provides standards for establishing specific cleanup goals at a particular site, recognizing that each site will have unique characteristics that must be evaluated and compared to those requirements that apply or are relevant and appropriate under the given circumstances. As described below, CERCLA actions may have to comply with three types of requirements: chemical-specific, location-specific, and action-specific requirements. Section 4.4 discusses potential chemical- and location-specific ARARs that may apply to the OU-2 IR sites. Potential action-specific ARARs will be identified as part of an FS of remedial alternatives should an unacceptable risk to human health or the environment be found at OU-2. The final determination of ARARs will be made if remedial action is selected for OU-2, and will be discussed in a ROD.

4.3.1 Chemical-Specific ARARs

Chemical-specific ARARs are health- or risk-based numerical values or methodologies that, when applied to site-specific conditions, result in establishment of remediation goals. These goals establish the acceptable amount or concentration of a chemical that may be found in or discharged to the ambient environment. An example of a potential chemical-specific ARAR is an MCL established under the Safe Drinking Water Act for a particular contaminant in groundwater if the groundwater is determined to be a drinking water source. If a chemical has more than one ARAR, the most stringent ARAR will be applied to any remedial action. When ARARs are not available or are not sufficiently protective of human health or the environment, remedial goals will be established through a site-specific risk assessment to ensure that exposure levels are within acceptable limits for protection of human health and the environment.

4.3.2 Location-Specific ARARs

Location-specific ARARs are restrictions placed on the concentrations of hazardous substances or the performance of remedial activities because of the characteristics of the site or its immediate environment. For example, the location of a site (or a proposed remedial action at that site) in a flood plain, wetland, historic place, or sensitive ecosystem may trigger location-specific ARARs.

4.3.3 Action-Specific ARARs

Action-specific ARARs are requirements for or limitations on specific potential remedial actions. The type and nature of these requirements depend on the particular remedial action to be taken at a site, and thus different actions or technologies are often subject to different action-specific ARARs. An example of an action-specific ARAR is a restriction prohibiting the discharge of organic compounds from an air stripper.

4.4 POTENTIAL CHEMICAL- AND LOCATION-SPECIFIC ARARS FOR OPERABLE UNIT 2

As the lead agency under CERCLA (Sections 300.400(g)(5) and 300.430(b)(9) of the NCP) at Alameda Point, the Navy is responsible for identifying potential federal ARARs. The Navy has made a preliminary identification of the potential federal chemical- and location-specific ARARs for the IR sites within OU-2. These potential federal ARARs are identified in Table 4-1.

In accordance with the NCP (40 CFR 300.515(h)(2)), the Navy is also responsible for requesting potential state requirements from the state support agency once site characterization data become available. The state is responsible for identifying and advising the Navy of potential state ARARs in a timely fashion. On October 24, 1994; October 4, 1995; and September 12, 1996, the Navy requested potential state ARARs from the California EPA (Cal/EPA) through DTSC, the state support agency for response actions at Alameda Point. In a letter dated November 13, 1996, DTSC responded to those requests.

For a state requirement to qualify as an ARAR, the requirement must be (1) a state law, (2) promulgated, (3) a substantive requirement, (4) from an environmental or facility siting law, (5) more stringent than the federal requirement, (6) identified in a timely manner, and (7) consistently applied. Moreover, when potential state requirements are identified, it is not sufficient for the state to provide a general "laundry

list" of statutes and regulations that might be ARARs for a particular site. Instead, the state must provide a list of requirements with specific citations of the section of law identified as the potential ARAR together with a brief explanation of why the requirements are considered to be applicable or relevant and appropriate to the site (NCP Preamble, 55 *Federal Register* 8666, 8746 [March 8, 1990]).

In DTSC's letter of November 13, 1996, the Navy received only a general listing of California statutes and regulations that may be ARARs for any number of sites at OUs 1 through 4. The list from Cal/EPA is not site-specific (DTSC 1996b). Additionally, the state has identified environmental laws and regulations that contain administrative not substantive requirements (such as 22 CFR § 66264.71) that are not promulgated (such as preliminary endangerment assessment guidelines) or that apply to off-site actions (such as discharges to publicly owned treatment works). Furthermore, many of the laws and regulations identified by the state contain requirements that are action-specific. It is premature to evaluate action-specific requirements as potential ARARs until the initial screening of remedial alternatives is conducted during the FS. Accordingly, the Navy has made its own evaluation of potential state chemical- and location-specific ARARs for OU-2. These potential ARARs are listed in Table 4-2 and may be further refined during the RI/FS process with input from the BCT.

4.4.1 Potential Chemical-Specific ARARs

Two media are associated with the OU-2 sites that may have chemical-specific ARARs: soil and water.

4.4.1.1 Soil

The Navy has identified no federal or state chemical-specific ARARs for soil at any OU-2 sites. However, because dioxins have been identified as COCs at Site 14, the Navy has identified EPA Office of Solid Waste and Emergency Response (OSWER) Directive 9200.4-26, "Approach for Addressing Dioxin in Soil at CERCLA and Resource Conservation and Recovery (RCRA) Sites" (April 13, 1998), as a TBC. This OSWER directive uses 1 part per billion (ppb) toxicity equivalents (TEQ) as the starting point for setting cleanup levels for dioxins in surface soils associated with residential exposure scenarios, and a range of 5 to 20 ppb for dioxins in surface soils associated with commercial or industrial exposure scenarios. This OSWER directive will be considered in establishing remediation goals should the risk to human health warrant evaluation of remedial alternatives in an FS. The Navy has identified no other chemical-specific TBCs for soils at this time.

4.4.1.2 Groundwater and Surface Water

The "Water Quality Control Plan of the San Francisco Bay Basin" (Bay Plan) (RWQCB 1995) has classified the groundwater of the East Bay Plain, which includes Alameda Point, as suitable for domestic use. The San Francisco RWQCB Groundwater Committee has proposed to de-designate from municipal and domestic use limited areas of East Bay Plain groundwater, which include portions of OU-2 at Alameda Point. As of late April 1999, the full RWQCB had not acted, and the SWRCB had not concurred with the de-designation proposal. Additionally, on February 23, 1998, the Navy submitted a technical memorandum to DTSC and EPA concluding that groundwater beneath the Central area, Site 14 area, and Site 25 area is not fit for municipal or domestic use and should not be considered a potential source of drinking water. Groundwater beneath the OU-2 Eastern and Southeastern areas, however, may be suitable for limited domestic use. The neighborhoods immediately east of these areas currently use the shallow groundwater for irrigation. No uses of shallow groundwater as a source of drinking water have been identified upgradient or downgradient of Alameda Point.

Because the usability of groundwater underneath a portion of OU-2 is under discussion but unresolved, the Navy will assume for the purposes of this RI the current beneficial use designations of the RWQCB in the Bay Plan. Accordingly, the Navy is identifying MCLs under Section 300g of the Safe Drinking Water Act (42 USC §300g-1) as potential chemical-specific ARARs for specific COCs in groundwater (see Table 4-1). The Navy will re-examine the beneficial use classification of groundwater before establishing remedial action goals in the OU-2 FS and will review its preliminary identification of MCLs as ARARs accordingly.

In addition, CERCLA Section 121(d)(2)(A) requires that remedial actions attain water quality criteria (WQC) established under Section 304 of the Clean Water Act (33 USC § 1314(a)), where such criteria are relevant and appropriate. At OU-2, several areas of groundwater contain COCs that have the potential to reach surface waters. Given the dilution expected during COC migration and discharge to surface water, it is doubtful that COCs in groundwater will exceed WQC. Nevertheless, the Navy has listed WQC in Table 4-1 that might be ARARs. The Navy has also identified the state water quality objectives in Table 3-3 of the Bay Plan as relevant and appropriate because groundwater COCs have the potential to reach the San Francisco Bay, the Seaplane Lagoon, or the Oakland Inner Harbor. These potential state chemical-specific ARARs are listed in Table 4-2.

4.4.2 Potential Location-Specific ARARs

The Navy has identified one potential location-specific ARAR. The Coastal Zone Management Act (16 USC § 1451 *et seq.*) requires that all federal activities affecting the coastal zone be conducted in a manner consistent with approved state management programs to the maximum extent practicable. The relevant state management plan for San Francisco Bay is contained in the bay plan prepared by the San Francisco Bay Conservation and Development Commission (BCDC) pursuant to the McAteer-Petris Act of 1965 (California Government Code Section 66600 *et seq.*). The Navy will conduct any remedial actions in accordance with the requirements of this bay plan.

TABLE 4-1
POTENTIAL FEDERAL CHEMICAL-SPECIFIC AND LOCATION-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS OU-2, ALAMEDA POINT

Statutory Citation	Regulatory Citation	Medium	Description	Preliminary ARARs Determination	Comments
Chemical-Specific Requirements					
Safe Drinking Water Act (42 USC §300g-1)	40 CFR Part 141: National Primary Drinking Water Regulations	Water	Establishes national primary drinking water standards for public water supply systems (MCLs)	Relevant and appropriate	If groundwater is determined to be a potential drinking water source, MCLs are potentially relevant and appropriate.
	EPA OSWER Directive 9200.4-26 (April 13, 1998).	Soils	EPA generally uses 1 ppb toxicity equivalents (TEQs) as the starting point for setting cleanup levels for dioxins in surface soils involving residential scenarios.	TBC	The EPA PRG for dioxin is useful guidance as a starting point for determining remediation goals for dioxins at Site 14.
Clean Water Act (33 USC § 1314(a))	40 CFR Part 131 Subpart D: Federally Promulgated Water Quality Standards	Water	Establishes water quality criteria (WQC) guidance for saltwater aquatic life protection	Relevant and appropriate	WQC are potentially relevant and appropriate for groundwater discharges to surface water.
Location-Specific Requirements					
Coastal Zone Management Act (16 USC § 1451(a)(1)(A))	Substantive provisions of 15 CFR Part 930	Water and soil	Activities that affect land or water use in coastal zone must be consistent with the state coastal zone management plan to the maximum extent practicable. The relevant plan is the San Francisco Bay Conservation and Development Commission Bay Plan.	Relevant and appropriate	Relevant to all sites in OU-2 at which remedial activities may affect the coastal zone.

Notes:

ARARs Applicable or relevant and appropriate requirement
CFR Code of Federal Regulations
MCL Maximum contaminant level
USC United States Code

TABLE 4-2
POTENTIAL STATE
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS
OU-2, ALAMEDA POINT

Statutory Citation	Regulatory Citation	Medium	Description	Preliminary ARAR Determination	Comments
Chemical-Specific Requirements					
Porter-Cologne Water Quality Control Act (California Water Code § 13304)	State Water Resources Control Board Amended Resolution No. 92-49: "Policies and Procedures for Investigation and Cleanup and Abatement under Section 13304 of the Water Code."	Water	Section III.G of Resolution No. 92-49 requires abatement of the effect of discharges in a manner that promotes attainment of either background water quality or the best water quality that is reasonable.	Relevant and appropriate	The relevance at each IR site will depend on the contaminant levels detected and the beneficial uses of groundwater.
Porter-Cologne Water Quality Control Act (California Water Code § 13000 *et seq.*)	23 CCR, Division 3, Chapter 15, Article 5	Water	Provides authority to ensure adequate protection of water quality and statewide uniformity in siting, operation, and closure of waste disposal sites; specifies procedures for groundwater monitoring and selecting corrective action levels	Relevant and appropriate	This may be relevant and appropriate at IR sites where discharges of waste affect water quality.
Porter-Cologne Water Quality Control Act (California Water Code §§ 13240 and 13241)	Water Quality Control Plans for the San Francisco Bay Region Basin, 1995, Sections 2 and 3	Water	Establishes beneficial uses of groundwater and surface water, water quality objectives, and implementation plans to protect beneficial uses and meet water quality objectives; incorporates statewide water quality control plans and policies	Relevant and appropriate	The relevance at each IR site will depend on the contaminant levels detected and the remedial action selected.
Hazardous Waste Control Law (California Health and Safety Code §§ 25100-25249)	22 CCR § 66261.10 22 CCR § 66261.20-66261.24 22 CCR § 66261.30-66261.35	Water and soil	Criteria for identifying characteristics of hazardous waste	Relevant and appropriate	The criteria are relevant and appropriate for determining whether wastes are hazardous wastes.

Notes:

ARAR	Applicable or relevant and appropriate requirement
CCR	California Code of Regulations
et seq.	And following
IR	Installation restoration

CHAPTER 5
RISK ASSESSMENT AND FATE AND TRANSPORT MODELING METHODOLOGIES

This chapter presents the HHRA and the ERA methodologies for the OU-2 RI. Risk assessment results are discussed on a site-specific basis in Chapters 6 through 10 for the OU-2 Southeastern, Eastern, and Central areas and for IR Sites 14 and 25, respectively. This chapter discusses the human health risk assessment in Section 5.1, the ecological risk assessment in Section 5.2, and the fate and transport modeling methodology in Section 5.3.

5.1 HUMAN HEALTH RISK ASSESSMENT

The HHRA is conducted as part of the RI under the Comprehensive Long-term Environmental Action Navy (CLEAN) program for the environmental restoration of naval facilities. The methodology for the HHRA is in accordance with the EPA's "Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual, Part A" (EPA 1989b).

The Navy and regulatory agencies could not agree on the use of a single HHRA methodology. Therefore, two sets of risk calculations are presented in the RI report because of technical differences between federal EPA, EPA Region IX, and DTSC. The technical differences are related to toxicity reference values (TRV), the dermal risk assessment, and exposure pathways. The two sets of risk calculations are based on the following assumptions:

- Assumptions based on federal EPA guidance (referred to as the "Navy assumptions" in this report)
- Assumptions made based on DTSC guidance (referred to as the "DTSC assumptions" in this report)

Some of the differences in toxicity values between the two databases are summarized in Table 5-1. Examples of these differences are discussed below.

- A comparison of the human health COCs identified in groundwater based on Navy and DTSC assumptions indicates that beryllium is a COC under DTSC assumptions but not under Navy assumptions. Recently, EPA reevaluated the carcinogenicity of beryllium. Previously, beryllium was considered to be a carcinogen by both the oral and inhalation routes of exposure, and carcinogenic TRVs were available for both exposure routes. However, during the reevaluation, EPA determined that the incidences of tumors in the control group and beryllium-exposed group were not statistically different. In the

absence of other relevant studies, the oral exposure route database was considered inadequate for an assessment of carcinogenicity, and the oral slope factor was withdrawn from the Integrated Risk Management System (IRIS) (EPA 1997b). The inhalation slope factor remained unchanged. DTSC has not reevaluated the oral carcinogenic TRV for beryllium. However, based on EPA's recent withdrawal of the oral slope factor for beryllium and the incomplete inhalation exposure pathway at OU-2, beryllium is not a COC in groundwater under the Navy assumptions.

- The difference in carcinogenic risks for soil under the two sets of assumptions results from higher cancer slope factors for PAHs and PCBs under DTSC assumptions and the difference in dermal assessment methodologies.

- In the DTSC database, 1,1-dichloroethane (1,1-DCA) is considered a carcinogen through the ingestion exposure pathway; however, 1,1-DCA is not considered a carcinogen through the ingestion exposure pathway in the EPA database (Navy method). The EPA database is updated more regularly; therefore, the Navy TRV is considered more appropriate.

- In the DTSC database, 1,4-dichlorobenzene (1,4-DCB) is considered a carcinogen through the ingestion exposure pathway; however, 1,4-DCB has not undergone a complete evaluation and determination under EPA's IRIS program (Navy method) for evidence of human carcinogenic potential. Until EPA completes its carcinogenic evaluation of 1,4-DCB, this chemical is considered an oral carcinogen consistent with the DTSC database.

All chemical risk drivers that exceed a 1.0×10^{-6} carcinogenic risk or a noncarcinogenic HI of 1.0 are detailed in Chapter 6 of the RI report and addressed in the risk management discussion and conclusions. The differences between the risk assessment assumptions are outlined on a site-specific and chemical-specific basis in Chapters 6 through 10. Metals and PAHs that have a site risk comparable to the risk from background concentrations are typically not identified as target chemicals for the FS. The purpose of the HHRA is discussed below.

5.1.1 Purpose

The purpose of the HHRA is to evaluate potential site-specific human health risks associated with exposure to chemicals detected at each IR site. Site-specific HHRAs conducted for Alameda Point estimate potential current and hypothetical future human health risks associated with possible exposure to site-related chemicals. Each HHRA was conducted using current data for chemical concentrations and site conditions for those future exposures. These baseline HHRAs were conducted without regard to future remediation activities or any attempt to control or mitigate chemical releases; however, reductions in chemical concentrations resulting from past remediation activities were considered.

Exposure assumptions used to estimate chemical intake were based on information presented in the following documents:

- Region IX PRGs (EPA 1998)
- "Exposure Factors Handbook" (EPA 1997a)
- "Human Health Evaluation Manual, Supplemental Guidance: Draft Standard Default Exposure Factors" (EPA 1991c)
- "Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part B, Development of Risk-based PRGs)" (EPA 1991a)
- "Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure" (EPA 1993b)
- "Supplemental Guidance for Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities" (DTSC 1992a and 1992b)
- "Dermal Exposure Assessment: Principles and Applications" (EPA 1992a)

Information on chemical toxicity is from the following sources:

- IRIS chemical files (EPA 1997b)
- "Health Effects Assessment Summary Tables, Annual Update FY 1995" (HEAST) (EPA 1995a)
- California Office of Environmental Health Hazard Assessment, Cal/EPA, "Criteria for Carcinogens" (Cal/EPA 1994)

The risk assessment methodology in EPA (1989b) is composed of the four following components:

- Data evaluation and identification of COCs
- Exposure assessment
- Toxicity assessment
- Risk characterization

These components are detailed in the following subsections. Selection of receptors is based on land uses discussed in Chapter 2.

5.1.2 Identification of Chemicals of Potential Concern

This section describes the methodology used to identify COPCs. COPCs are defined as chemicals that are potentially site-related, potentially toxic, and meet data quality criteria for risk assessment. Evaluating site-specific data is the first step in quantifying risks and identifying potential hazards at each site. Soil and groundwater sampling data were collected within and near the OU-2 IR sites through several sampling efforts. Resulting data were used to characterize the sites. In general, the data were collected and analyzed in accordance with EPA's CLP procedures, and detection limits (sample quantitation limits [SQL]) were sufficiently low to permit identification of potential health risks. The majority of data were validated with respect to laboratory blank and QC sample results, and qualifiers were determined by independent validators. Field data and screening-level data were not used in this HHRA to estimate health risks and HIs. For this reason, data collected as part of the EBS were excluded from the HHRA for the RI. Data quality assessment is described in detail in Chapter 3 of this RI report. Site-specific HHRA data evaluation is described for each site in Appendix D.

The OU-2 sites are relatively small, and site boundaries were used to define exposure unit size. The data summaries for each site are presented in Appendix D. Soil data for each site are grouped according to the following depth intervals: 0 to 2 feet bgs, 0 to 10 feet bgs, or depth to groundwater, whichever was more shallow. FWBZ groundwater data are also grouped for the OU-2 Southeastern, Eastern, and Central areas and for IR Sites 14 and 25. The data summaries provide the arithmetic mean and upper confidence limit (UCL) of the arithmetic mean concentrations for every chemical detected at least once in soil or groundwater. The probability density function (PDF) was determined for each chemical from detected values. A PDF could not be determined if the chemical was detected fewer than five times. One-half the SQL was used as a proxy value for nondetected results to calculate descriptive statistics (that is, mean, 95 UCL, and standard deviation values).

After the data summary, human health COPCs were selected using screening criteria recommended by EPA guidance (EPA 1989b). These criteria are essential nutrient status, frequency of detection, and a site-specific background comparison. Figure 5-1 presents a flowchart describing the human health COPC selection process that was used for each OU-2 site.

According to EPA guidance (EPA 1989b), the essential human nutrients that can be eliminated as human health COPCs are calcium, iron, magnesium, potassium, and sodium. Even if these chemicals are present

at concentrations above naturally occurring levels, they were eliminated as COPCs because they are toxic at only very high doses. In fact, TRVs for these chemicals have not been developed.

A frequency of detection criterion is used because chemicals detected infrequently can be sampling and analytical artifacts or spurious data (EPA 1989b). These chemicals can be eliminated if there is no reason to believe that the chemicals may be present as a result of site-related activities. A detection frequency limit of 5 percent is conventionally used as a benchmark for elimination. This criterion also involves evaluating chemicals for historical site use, concentration, toxicity, mobility, persistence, and bioaccumulation. Therefore, any chemical considered for elimination under this criterion was also screened against one-tenth of the EPA Region IX PRGs (EPA 1998) to determine whether it could potentially pose a risk to human health. Chemicals were only eliminated as human health COPCs if they were detected at a low frequency and their maximum concentration was below one-tenth of the EPA Region IX PRGs for residential land use. In general, chemicals eliminated based on the frequency of detection criterion were detected at concentrations far below one-tenth of the PRGs (usually one-hundredth to one-thousandth of the PRG). No effect on HHRA results would have resulted if these chemicals had been retained.

The comparison between site-specific background data and site data used a toolbox approach that included a "hot spot" comparison, as well as parametric and nonparametric tests of means for inorganic chemicals. Figure 5-2 presents a flowchart outlining the statistical toolbox approach used for Alameda Point; details of the statistical methodology are presented in the "Final Statistical Methodology for Background Comparisons" report (PRC 1997c). The tests of means were conducted at a significance level of 0.95 (alpha = 0.05) and power of 0.90 (beta = 0.10), which exceed EPA's minimum recommendations (EPA 1990a). A hot spot evaluation was conducted for each inorganic chemical using a DTSC methodology discussed in the background comparison methodology report (PRC 1997c). The 80 LCL/95 was calculated for each inorganic analyte in the site-specific background. The maximum detected concentration of each inorganic chemical at each site was compared to the 80 LCL/95 site-specific background concentration. If the calculated 80 LCL/95 exceeded the maximum detected site-specific background concentration for a chemical, the maximum detected value was used for the comparison. Hot spots were determined by identifying samples that had concentrations above the 80 LCL/95 threshold value. The results of this hot spot comparison, together with the results of the statistical tests of means, were used to determine whether an inorganic chemical exceeded site-specific background concentrations. If an inorganic chemical exceeded its site-specific background concentration, it was identified as a COC.

The results of the human health COPC selection process for the HHRA in soil and groundwater for each OU-2 site are summarized in Chapters 6 through 10 for the OU-2 Southeastern, Eastern, and Central areas and for IR Sites 14 and 25, respectively. Tables presented in these chapters list human health COPCs for soil in the 0- to 2-foot-bgs and 0- to 10-foot-bgs depth intervals, groundwater in the FWBZ, all detected chemicals at each site, results of the human health COPC selection process, and reasons for exclusion as a COPC. Details of the human health COPC selection method for each site are presented on a site-specific basis in Appendix D.

5.1.3 Exposure Assessment

An exposure assessment includes an evaluation of potential human receptors that could come in contact with site-related COCs, as well as exposure routes, magnitude, frequency, and duration of exposure. An evaluation of all possible human exposures is necessary to identify receptors that are in current contact with or could come in contact with Alameda Point COCs in the future. The principal objective of this evaluation is to identify exposures that represent reasonable maximum exposure (RME) and average exposure (AVG) scenarios at Alameda Point (EPA 1992b). The concept of reasonable scenarios underlies the RME concept developed by EPA. As defined by EPA, the RME is the maximum exposure that is reasonably expected to occur at a site (EPA 1989b). It should be emphasized, however, that the RME exposure is for the same receptor and that before risks are calculated, it must be determined whether "it is likely that the same individual would consistently face the RME" (EPA 1989b, emphasis not added).

It is also important that intake variable values for each RME exposure pathway should be "selected so that the combination of all intake variables results in an estimate of the RME for that pathway" (EPA 1989b). In other words, the most conservative intake variables for each parameter for a given pathway are not used exclusively. A combination of average and upper-bound values should be combined to estimate exposures that are meaningful and represent the actual RME for the site.

The exposure assessment for the OU-2 sites included the following steps:

- Characterization of the exposure setting(s) and identification of potential future human receptors
- Identification of exposure pathways and exposure routes

- Estimation of exposure point concentrations
- Quantification of chemical intake for pathway specific exposures for each potential receptor

Following EPA guidance (EPA 1989b), all complete exposure pathways were selected for evaluation unless one or more of the following applied:

- Exposure from one pathway is likely to be much less than that from another pathway involving the same medium and the same exposure point.
- The potential magnitude of exposure from a pathway is likely to be very low.
- The probability of the exposure occurring is very low, and the risks associated with the pathway are low.

The following sections discuss the exposure setting and potential receptors (Section 5.1.3.1), identification of exposure pathways and routes (Section 5.1.3.2), estimation of exposure point concentrations (Section 5.1.3.3), and quantification of chemical intakes for pathway-specific exposures for each potential receptors (Section 5.1.3.4).

5.1.3.1 Exposure Setting and Potential Receptors

According to EPA (EPA 1989b), the first step in evaluating current or potential future chemical exposures is an evaluation of the physical characteristics of the site (such as climate, vegetation, soil type, and hydrology of surface water and groundwater) that are pertinent to the risk assessment. Soil and groundwater are media of concern at the OU-2 sites because surface water and sediment are not contained within OU-2 site boundaries.

Historical data indicate that shallow groundwater in the East Bay Plain area is affected by high nitrate concentrations and saltwater intrusion (Alameda County Flood Control and Water Conservation District [ACFCWCD] 1988).

As discussed in Section 2.3, the Bay Sediment Aquitard separates the artificial fill (FWBZ) and Merritt Sand Formation (SWBZ) in the western and central regions of Alameda Point. The SWBZ is generally brackish to saline. A deeper fresh water aquifer (Alameda Formation) is separated from the FWBZ and SWBZ by a thick impermeable layer consisting of the Yerba Buena Mud Aquitard. The FWBZ and

SWBZ were sampled as part of the RI activities. All sites in OU-2 contained detectable concentrations of chemicals in the FWBZ and SWBZ (where present) related to site activities. Groundwater samples were not collected from the Alameda Formation. The California RWQCB, San Francisco Bay Region, has identified the groundwater basin in which Alameda Island lies for potential use as "domestic or municipal supply, industrial process supply, industrial service supply, and agricultural supply" (RWQCB 1986). However, RWQCB indicates that "local groundwater quality conditions may vary significantly, due to natural factors, making some groundwater supplies unsuitable for the uses indicated" (RWQCB 1986). Because RWQCB has not yet made a final decision regarding potential groundwater use(s) of the shallow aquifer at Alameda Point, it is assumed that the groundwater could be used for all indicated uses, including domestic or municipal water supply.

No consistent exposure scenarios currently exist at the IR sites at Alameda Point. Some security personnel patrol the base and some administrative and maintenance personnel remain at the base. Occasional recreational activities at the base may consist of jogging, walking, and picnicking, but these activities do not occur at OU-2 IR sites. Although not associated with IR sites, residential housing is located in the northeastern corner of the installation. Some buildings at Alameda Point are leased for occupational use. Because the future exposure scenarios involve a greater extent and duration of exposure, only future exposure scenarios and parameters were used to evaluate risks associated with these scenarios.

Residential, occupational, and recreational exposures are the most reasonable exposure scenarios for future land use at the OU-2 IR sites. Construction worker exposures are also possible and were evaluated for most of the OU-2 IR sites. Although EPA (EPA 1989b) requires that the future land use be based on professional judgment and recognizes that "an assumption of future residential land use may not be justifiable if the probability that the site will support residential use in the future is exceedingly small," DTSC generally requires that a residential scenario be evaluated. Accordingly, residential land use has been evaluated for Alameda Point OU-2 sites except when future land use is known to be nonresidential or when laws or zoning prohibit housing development. Areas where residential housing is precluded include landfills and wetlands. The identification of potential receptors and land reuse was based solely on reuse plans for the base developed by ARRA (ARRA 1996).

Based on reuse plans developed for Alameda Point, future exposure scenarios listed in Table 5-1 are considered potentially complete for future use of OU-2 IR sites.

5.1.3.2 Identification of Exposure Pathways and Exposure Routes

All relevant exposure pathways will be evaluated for current and future occupational, recreational, and residential exposure scenarios.

According to EPA guidance (EPA 1989b), an exposure pathway consists of the following four elements:

- A source and mechanism of chemical release
- A retention or transport medium (or media in cases involving transfer of chemicals)
- A point of potential human contact with the contaminated medium (referred to as the "exposure point")
- An exposure route (such as ingestion) at the contact point

Eliminating any of these elements (except when the source itself is the point of exposure) results in an incomplete exposure pathway. Therefore, if no receptors exist that would contact the source or transport medium, the pathway was considered incomplete and therefore was not evaluated.

Routes of potential exposure associated with occupational, recreational, and residential exposure at OU-2 sites are the following:

- Recreational and occupational (including construction workers): Incidental soil ingestion, dermal contact with soil, inhalation of particulates, and inhalation of volatilized chemicals
- Residential: Incidental soil ingestion, dermal contact with soil, inhalation of particulates, ingestion of homegrown produce, inhalation of volatilized chemicals, groundwater ingestion, dermal contact with groundwater, and inhalation of volatilized chemicals while showering

Because these pathways are based on future exposures, they are considered potentially complete and were evaluated to provide a conservative estimate of risk. Not all of these pathways may be complete for all receptors in the future.

Figures 5-3a, 5-3b, and 5-3c present conceptual site models that indicate which exposure pathways are complete for each exposure scenario. Table 5-2 summarizes exposure scenarios and pathways evaluated at each site.

5.1.3.3 Estimation of Exposure Point Concentrations

Exposure point concentrations for chemicals in each medium were estimated for each OU-2 IR site using the IR database. DQOs were evaluated for data usability, and it was determined that combining data from different IR sampling efforts was permissible. For building interiors, a model was used to estimate concentrations of volatile chemicals in air from measured concentrations in soil and groundwater (Johnson and Ettinger 1991). Particulate concentrations were also estimated using a particulate emission factor (PEF) recommended by DTSC (DTSC 1994). Groundwater monitoring well data were used to calculate exposure point concentrations for groundwater exposure pathways. For soil, a sampling depth interval of 0 to 2 feet bgs was used for recreational and occupational exposure assessments, and a depth interval of 0 to 10 feet bgs (or depth to groundwater, whichever is shallower) was used for the residential and construction worker exposure assessments. Soil data representing the most current site conditions were used to estimate exposure point concentrations.

Within each medium, descriptive statistics were calculated for all chemicals detected. The PDFs and either the arithmetic or geometric mean were determined for inorganic chemicals, and the arithmetic mean was calculated for organic chemicals. In accordance with recent EPA guidance (EPA 1992c), the 95 UCL of the arithmetic mean was calculated and used as the exposure point concentration in the HHRA to estimate chemical intakes. The 95 UCL of the arithmetic mean is defined as a value that, when calculated repeatedly for randomly drawn subsets of site data, equals or exceeds the true mean 95 percent of the time (EPA 1992c). The 95 UCL is a better predictor of actual chronic exposure conditions because it is based on the probability of long-term random contact with contaminated areas. However, in areas where the 95 UCL concentration exceeded the maximum chemical concentration, the maximum concentration was used as the exposure point concentration.

5.1.3.4 Quantification of Chemical Intake for Pathway-Specific Exposures for Each Potential Receptor

This section of the HHRA estimates chemical intake rates for all complete exposure pathways based on the exposure point concentrations and the estimated magnitude of exposure to contaminated media.

Exposure is based on "intake," which is defined as the mass of a substance taken into the body per unit body weight per unit time. Intake from a contaminated medium is determined by the amount of the chemical in the medium, the frequency and duration of exposure, body weight, the contact rate, and the averaging time. The following is a generic algorithm that is used to calculate chemical intake:

$$I = \frac{C \times CR \times EF \times ED}{BW \times AT}$$

where

I	=	Intake (milligram per kilogram (of body weight)-day [mg/kg-day])
C	=	Chemical concentration in contaminated medium (mg/kg or mg/L)
CR	=	Contact or ingestion rate (milligrams per day [mg/day] or liters per day [L/day])
EF	=	Exposure frequency; how often exposure occurs (days per year)
ED	=	Exposure duration; how long exposure occurs (years)
BW	=	Body weight (kilogram [kg])
AT	=	Averaging time; period over which exposure is averaged (days)

Chemical intake through ingestion and inhalation is quantified as an administered dose. However, chemical intake from dermal exposure is estimated as an absorbed dose. Dermal contact equations have additional exposure parameters of adherence and absorption factors or permeability constants. Adherence factors indicate the amount of soil that adheres to the skin. Absorption factors reflect the desorption of the chemical from soil and absorption of the chemical across the skin. The permeability constant represents the rate at which a chemical in water penetrates the skin. Dermal absorption factors from the "Preliminary Endangerment Assessment (PEA) Guidance Manual" (DTSC 1994) were used for dermal exposure estimates. Dermal absorption factors used in the assessment of dermal intake using DTSC methodologies are presented in tabular form in Appendix D.

As previously noted, EPA (1992b) requires that exposure parameters used to determine contaminant intakes for a given pathway be selected so that the estimated intake represents exposure under the AVG and RME cases. Site-specific and EPA default values for exposure parameters were used in the Alameda Point HHRA. Intake equations and exposure parameters used to estimate chemical intake associated with exposure to contaminated media for recreational, residential, and occupational receptors are presented in tabular form in Appendix D. Both RME and AVG case intakes for future receptors (including recreational, residential, and future occupational receptors) were calculated. Results of these calculations are presented in the site-specific HHRAs in Chapters 6 through 10, as well as in Appendix D.

Site-specific exposure parameters for recreational receptors were identified from several sources. Current access and potential land use were evaluated to select exposure factors. Parameters for recreational receptors were selected from the "Exposure Factors Handbook" (EPA 1997a) and DTSC guidance (DTSC 1994) and were based on the types of activities expected to occur in open space areas planned for these sites. Use of site-specific recreational parameters will ensure that calculated risks and HIs are "an estimate of RME for that pathway" as specified by EPA guidance (EPA 1989b). Activity patterns for recreational receptors were based on site-specific information and the assumption that recreational activities are related to use of a community park. A community park is assumed to be used more frequently by the same people than a regional or national park (Johnson and Ettinger 1991) because of its proximity to homes and offices.

VOCs in groundwater were evaluated for volatilization to the interior of residential and occupational buildings using a modified model specific to Alameda Point. The method was based on the Johnson and Ettinger model theory: "one can assume, without any loss of generality, that contaminant levels in the soil moisture and vapor phases are (in equilibrium and therefore can be) related by a Henry's Law Constant, H (cm^3 of water/cm^3 of vapor): $C_v = HC_M$." In this equation, C_v is the concentration of a chemical in vapor and C_M is the concentration of that chemical in soil moisture. It was assumed that all VOCs in groundwater will be able to vaporize (that is, that the VOCs are not bound to particulates or otherwise impeded from volatilization), and vapor concentration was estimated as the concentration in groundwater and subsurface soil multiplied by the Henry's Law Constant. The subsurface soil concentration was also divided by the soil-water partition coefficient to convert the soil concentration from units of mg/kg to units of mg/L, multiplication of that value by the dimensionless Henry's Law Constant results in a soil gas concentration estimate. The vapor concentration was then divided by a dilution factor of 100,000 based on a study conducted by Lawrence Berkeley Laboratory at Alameda Point (Fischer and others 1996). Briefly, this study determined that concentrations of chemicals in the vapor phase are diluted by a

factor of 1 million between gas at 0.7 meter (m) bgs and the interior of the overlying building. Although this study reports a decrease of six orders of magnitude, a slightly more conservative dilution factor of five orders of magnitude was used in this risk assessment to account for any differences that may occur at other sites or buildings. The results obtained using this methodology were previously compared to the American Society for Testing and Materials (ASTM) model recommended by DTSC and found to be comparable. Chemical constants and volatilization factors used in the assessment of inhalation of volatile chemicals are presented in tabular form in Appendix D.

Inhalation of particulates and volatile chemicals from soil in ambient air was evaluated for every receptor. For residential and occupational receptors, it was conservatively assumed that the estimated ambient air concentrations were the same for both indoor and outdoor exposure scenarios. Outdoor ambient air concentrations are generally higher than indoor ambient air concentrations. Also, the exposure time was not divided into time spent outdoors versus time spent indoors, although usually more time is spent indoors and, generally, such a division would result in lower intakes of chemicals. Instead, the entire exposure time and the outdoor ambient air concentrations of chemicals were used to estimate chemical intakes through these exposure pathways. The resulting exposure estimates were conservatively used to represent both indoor and outdoor inhalation exposures for these two exposure pathways.

5.1.4 Toxicity Assessment

The toxicity assessment focuses on Alameda Point human health COPCs, which are chemicals that pose the greatest threat to human health. Standard toxicological methodologies for assessing the toxicity of chemicals involve quantifying the dose-response relationships for adverse human health effects associated with exposure to specific chemicals. For carcinogenic health effects, carcinogenic slope factors (CSF) are used to estimate the incremental lifetime cancer risk (ILCR) of developing cancer as a result of chemical intake. CSFs correspond to specific routes of exposure. The potential for noncarcinogenic adverse health effects for oral exposures is typically evaluated by comparing estimated daily intakes with reference doses (RfD), which represent daily intakes at which no adverse health effects are expected to occur. Reference concentrations (RfC) present the same information for inhalation exposures; RfCs are typically converted to units of mg/kg-day and called inhalation RfDs for the purposes of HI calculations.

Qualitative and quantitative toxicity values and EPA and DTSC-derived toxicity values were gathered for all Alameda Point human health COPCs. Detailed toxicity profiles were prepared for each human health COPC. Sources of toxicity values include IRIS chemical files (EPA 1997b); HEAST (EPA 1995a); the

Cal/EPA Office of Environmental Health Hazard Assessment (Cal/EPA 1994); and the Superfund Technical Support Center (STSC 1998). IRIS is a computerized EPA database containing verified TRVs and up-to-date human health toxicological and EPA regulatory information for the most commonly used chemicals. HEAST is a source of unverified provisional toxicity information used when toxicity information is not available from the IRIS database. The STSC provides provisional toxicity information on a chemical-specific basis when values are not available from either the IRIS database or HEAST. Carcinogenic chemicals and associated risks are evaluated and presented separately from noncarcinogenic chemicals in the Alameda Point HHRA.

Human health COPCs that do not have EPA-derived TRVs for exposure routes relevant to Alameda Point exposures are identified in the toxicity profiles and have been qualitatively evaluated in the risk characterization for each site in Appendix D. In the case of dermal exposure, oral toxicity values were substituted for dermal toxicity values, but no adjustment was made to the oral RfDs and CSFs to take into account differences in gastrointestinal and dermal absorption in accordance with EPA Region IX guidance (EPA 1998). DTSC also prefers the use of unadjusted TRVs for estimating risks and HIs from dermal exposure. Many chemicals have oral toxicity values but no inhalation toxicity values. According to EPA guidance (EPA 1996c), a route-to-route extrapolation is generally not recommended with the possible exception of the following chemicals: acetone; bromodichloromethane; chlorodibromomethane; cis-1,2-dichloroethene (cis-1,2-DCE); trans-1,2-DCE; 2-chlorophenol; dichlorodiphenyldichloroethylene (DDE); 2,4-dichlorophenol; 2,4-dinitrotoluene; 2,6-dinitrotoluene; gamma-hexachlorocyclohexane (HCH); isophorane; n-nitrosodi-n-propylamine; and pentachlorophenol. For these 14 chemicals only, the oral toxicity values are directly extrapolated to the inhalation pathway. This procedure does not account for route of administration, target organ, portal of entry effects, or other physicochemical effects as required by EPA guidance (EPA 1994c; STSC 1998) but was requested by the EPA Region IX toxicologist. Route-to-route extrapolation in this manner increases the uncertainty of the risk assessment results. A summary of TRVs for human health COPCs for OU-2 sites is presented in tabular form in Tables 5-3 and 5-4 and Appendix D along with toxicity profiles for each human health COPC.

Toxicity assessments for carcinogens, noncarcinogens, and lead (metal) are discussed below.

5.1.4.1 Carcinogenic Chemicals

The following information for each carcinogenic human health COPC is presented in Appendix D:

- The current CSF from EPA and DTSC databases
- Weight-of-evidence classification
- Type of cancer for Class A carcinogens

Toxicity equivalency factors (TEF) for dioxins and PAHs from DTSC were used to adjust TRVs for chemicals relative to 2,3,7,8-tetrachlorodibenzodioxin and benzo(a)pyrene, respectively (Cal/EPA 1994).

5.1.4.2 Noncarcinogenic Chemicals

The following information was gathered from all available sources and presented for all noncarcinogenic human health COPCs and is presented in Appendix D:

- Current RfDs and RfCs and the toxicological basis for these values
- Overall database and critical study on which the TRVs are based
- Target organs and uncertainty factors
- Possible biochemical mechanism(s) of toxicity

5.1.4.3 Lead Assessment

Risks and HIs are not evaluated for lead in the same manner as other human health COPCs because EPA and Cal/EPA have developed physiologically based modeling approaches. These approaches evaluate the intake and subsequent blood lead levels of receptors based on residential exposure to soil and groundwater. Cal/EPA's Lead Model estimates the blood lead levels in children and adults at the 99th percentile of exposure to specific concentrations of lead in various media (for example, soil, water, and air).

EPA uses 400 mg/kg of lead in soil as a screening value (EPA 1996a). Cal/EPA uses 130 mg/kg as a screening value for residential exposure (EPA 1996a). When a 95 UCL exposure concentration to lead exceeded 130 mg/kg at OU-2 sites, EPA's lead model was used to assess lead exposures.

5.1.5 Uncertainty

Various degrees of uncertainty are associated with each stage of the HHRA from assumptions made during the risk assessment and limitations of the data used to calculate risk estimates. Uncertainty and variability are inherent in the exposure assessment, TRVs, and risk characterization. EPA guidance states the following (emphasis not added) (EPA 1989b):

> There are several categories of uncertainties associated with site risk assessments. One is the initial selection of substances used to characterize exposures and risk on the basis of the sampling data and available toxicity information. Other sources of uncertainty are inherent in the toxicity values for each substance used to characterize risk. Additional uncertainties are inherent in the exposure assessment for individual substances and individual exposures. These uncertainties are usually driven by uncertainty in the chemical monitoring data and the models used to estimate exposure concentrations in the absence of monitoring data, but can also be driven by population intake parameters. Finally, additional uncertainties are incorporated in the risk assessment when exposure to several substances across multiple pathways are summed.

EPA defines uncertainty as a "lack of knowledge about specific factors, parameters or models" including "parameter uncertainty (measurement errors, sampling errors, and systematic errors), model uncertainty (uncertainty due to necessary simplification of real-world processes, mis-specification of the model structure, model misuse, use of inappropriate surrogate variables), and scenario uncertainty (descriptive errors, aggregation errors, errors in professional judgment, incomplete analysis)" (EPA 1997c). Variability is defined as "observed differences attributable to true heterogeneity or diversity in a population or exposure parameter" (EPA 1997c). Variability is the result of natural random processes such as variations in body weight, breathing rate, or drinking water rates. Variability cannot be reduced by further study but may be better characterized through further measurements.

For OU-2 sites, the selection of substances for inclusion in the risk assessment was conservative. The only chemicals not quantitatively evaluated in the risk assessment are (1) essential nutrients, (2) chemicals detected at concentrations below site-specific background concentrations (inorganic chemicals only), and (3) chemicals infrequently detected and below one-tenth of the EPA Region IX PRG for that chemical. Therefore, all chemicals that are not essential nutrients detected in soil or groundwater at concentrations exceeding site-specific background concentrations with a frequency of detection greater than 5 percent or at a concentration greater than one-tenth of the PRGs were evaluated in the HHRAs. It is unlikely that chemicals eliminated from the risk assessment were either site-related or would have posed a significant health risk. The uncertainty related with this component of the risk assessment is likely to result in an overestimate of risk resulting from inclusion of chemicals that are not site-related.

Also, no decrease in chemical concentrations over time was assumed to occur. This also results in a more conservative risk estimate.

Tentatively identified compounds (TIC) are another source of uncertainty in risk assessments. TICs are reported from VOC and SVOC analyses performed on environmental samples using GC/MS. TICs are nontarget compounds that the data quantitation software identifies through the comparison of a compound's mass spectrum to that of known mass spectra stored in a standardized National Institute of Standards and Technology mass spectral database or "library." This "library search" identifies a nontarget compound by either (1) a specific compound name such as "cyclohexane," (2) by chemical class such as "alkyl aromatic hydrocarbon," or (3) as an "unknown." According to EPA guidance, "the assigned identity is in most cases highly uncertain" (EPA 1989b).

TICs identified in samples collected from Alameda Point were frequently identified as belonging to classes of compounds associated with petroleum hydrocarbons or as unknowns. It is not possible to quantify a risk for a chemical that is only broadly identified by chemical class or as an unknown. Therefore, TICs were not included in the COC selection process. Because of the large number of target analytes identified in the RI samples collected at Alameda Point, the effect of TICs on the outcome of the risk assessment would likely have been insignificant.

Uncertainties associated with the TRVs in the HHRA include the following:

- Unknown differences between humans and laboratory animals in chemical absorption, distribution, metabolism, and excretion, which can greatly affect toxicity values
- Validity and quality of scientific studies that form the basis of EPA and DTSC-derived TRVs
- Statistical models used to extrapolate from high to low doses in animals to develop TRVs
- The basic underlying assumption in the dose-response model for carcinogens that there is no threshold involved in the pathogenesis of cancer
- Routine use of the 95 UCL of the CSF

In general, TRVs are developed to be protective of sensitive receptors and are likely to overestimate the chemical's toxicity. TRVs have not been developed for all chemicals; however, in these cases, risk or HIs may be underestimated. TRVs may not be available for a variety of reasons, including that a chemical may not have been studied; studies conducted were inconclusive; or the chemical has been studied only as

part of a mixture and no chemical-specific information was generated. In each case, the lack of a TRV is likely to cause an underestimate of risk. The magnitude of the underestimation is unknown because lack of a TRV indicates the lack of any reliable toxicity information. Also in this assessment, TRVs were used to assess risks from dermal exposure without adjustment for gastrointestinal absorption efficiency. This may result in an underestimate of risk the magnitude of which is inversely proportional to the gastrointestinal absorption of the chemical.

The exposure assessment relies on current and predicted future uses of the land and the parameters that are available to estimate the magnitude and duration of exposures associated with those land uses. In many cases, the land uses are known; however, the range of exposure parameters available may lead to a wide range of risk estimates. In this risk assessment, reuse plans developed by ARRA were used to select future potential receptors. For many sites, this included residential, occupational, recreational, and construction worker exposure scenarios. Some sites do not have a planned residential reuse but were evaluated for residential exposures despite a low likelihood of residential development.

Variability and uncertainty are also related to exposure parameters used in the risk assessment. Variability in exposure duration and frequency, as well as breathing rates, soil ingestion rates, and amount of dermal contact with soil, can be substantial. In this risk assessment, the RME and AVG cases were characterized for each receptor. The use of default RME exposure parameters, however, leads to a compounding of conservative assumptions that likely overestimates risk. The default RME parameters are selected to be representative of the 95th percentile of exposure or higher for each exposure pathway. For residential RME exposure, for example, a person is assumed to be exposed to the site 24 hours per day, 350 days per year, for 30 years. The AVG parameters represent the average or median exposures under each scenario. These values, particularly for exposure frequency and duration, may be more representative of expected exposures. It is important to note that there are many different combinations of exposure parameters that will result in risk estimates between the RME and AVG risks presented here. To calculate total risks and HIs, the chemical-specific risks for each exposure pathway are summed. According to EPA guidance, "uncertainties associated with summing risks or HIs for several substances are of particular concern in the risk characterization step. The assumption of dose additivity ignores possible synergisms or antagonisms among chemicals, and assumes similarity in mechanisms of action and metabolism. Unfortunately, data to assess interactions quantitatively are lacking" (EPA 1989b). EPA guidance recommends summing the risks and HIs in order to avoid underestimating cancer risks or potential noncarcinogenic health effects at a site despite the concerns stated above (EPA 1989b). Summing the risks and HIs may overestimate results because similarity in mechanisms of action and

metabolism are assumed to be similar and because potential antagonistic effects are ignored. It is also possible that total risks and HIs may be underestimated because potential synergistic effects are ignored.

Overall, RME risks and HIs presented in this HHRA for each site are conservative estimates and are more likely to overestimate risks than to underestimate them. The estimates presented here are single-value results intended to provide a range of values. However, rarely do single point estimates accurately represent actual exposures, and much information on variability is lost by using point-estimates of exposure rather than distributions. As stated in DTSC guidance, "uncertainty and variability in the movement of the chemical across the environment as well as the nature of the potential human exposures mean that the risk is more accurately characterized by a range or distribution" (DTSC 1995). When making decisions based on risk estimates, the range of risks should be considered.

5.2 ECOLOGICAL RISK ASSESSMENT

The following sections summarize the methods used for the OU-2 ERA. The methods are consistent with the requirements of DTSC (1996a) and EPA (1997c). The methods used follow the steps and processes presented in EPA (1997c). Specifically, the ERA presented for OU-2 corresponds to the Steps and Scientific/Management Decision Points (SMDP) Numbers 1 and 2 as described in EPA (1997c). SMPDs 1 and 2 consist of (1) screening-level problem formulation and ecological effects evaluation and (2) screening-level preliminary exposure estimate and risk calculations.

Screening-level ERAs rely on existing data and generally do not include site-specific studies such as bioassay testing. Based on the available data set (and corresponding uncertainties), a primary objective of the screening ERA is to minimize the probability of a Type I error (that is, underestimating site risks and taking no action when unacceptable risks exist). Therefore, toxicity and exposure assumptions used in screening-level ERAs are normally conservative and intended to represent reasonable worst-case conditions. This usually results in overestimation of site-related risks. Results of the screening-level ERA are generally used to (1) eliminate specific sites, exposure pathways, and ecological COPCs from further consideration; (2) make recommendations for additional monitoring; or (3) proceed to a baseline ERA.

However, OU-2 is highly developed with almost no current habitat, and the existing groundwater and soil sampling and analysis database is extensive. Based on the large amount of site-specific data available and the limited opportunity for further analysis, a range of potential risk values were developed for all OU-2

sites. The different risk values rely on different exposure assumptions that range from extremely conservative to more representative of existing site conditions. This range of risk values will assist Navy, EPA, and DTSC risk managers in making informed risk management decisions related to OU-2 sites.

Overall, potential risks to ecological receptors are conservatively quantified based on the following: (1) identification of habitats and biota that may be affected by contaminants detected at the OU-2 sites (see Section 5.2.1); (2) identification of exposure pathways (see Section 5.2.2); (3) development of ecological COPCs for each site based on existing soil and groundwater data (see Section 5.2.3); (4) assessment and measurement endpoints (see Section 5.2.4); and (5) ecological effects evaluation, including development of TRVs and corresponding hazard quotients (HQ) (see Section 5.2.5). Results of the screening-level ERA are presented in Section 5.2.6.

5.2.1 Identification of Habitats and Biota

Habitat and biota were assessed through reviewing site-specific literature and data, conducting a site reconnaissance in June 1995 and June 1997, and conducting a site visit in October 1998.

Terrestrial habitat types and plant and animal species (potential ecological receptors) observed and expected at Alameda Point were identified. Site reconnaissance and previous studies were used to identify terrestrial plants and animals. The following literature sources were used:

- "Alameda Naval Air Station's Natural Resources and Base Closure" (Golden Gate Audubon Society [GGAS] 1994)
- "Final Environmental Impact Statement - Candidate Base Closures and Realignment, San Francisco Bay Area" (Navy 1990b)
- "Natural Resources Management Plan, Naval Air Station, Alameda, California" (Navy 1988)
- "Final Environmental Impact Statement: Home Porting Battleship Battle Group/Cruiser Destroyer Group" (Environmental Science Associates [ESA] 1987)
- "Results of Wetland Survey of Runway 25 Apron Margin, Alameda Point". (Navy 1994b)
- "Naval Air Station Alameda, Waste Extraction Test (WET) Analysis" (The Habitat Restoration Group [HRG] 1993)
- "Planting Plan: Recreational Vehicle Campground" (Navy 1992)

- "Planting Plan: Landscape Parking Lot #40" (Navy 1990c)
- "Planting Plan: Waterfront Park Picnic Area" (Navy 1989)
- "Planting Plan: Waterfront Park, Fuel Tank Area" (Navy undated)
- "Planting Plan: Entrance Mall Repair at Main Gate" (Navy undated)

Detailed site reconnaissance of the OU-2 sites was conducted in June 1995 to augment information from the above literature sources. The protocol developed by the EPA Region IX Biological Technical Advisory Group (BTAG) (RWQCB undated) and presented in the site reconnaissance work plan (PRC 1995a) was used during the site reconnaissance. Weather conditions during the site reconnaissance consisted of mostly clear skies, approximate daytime temperatures of 75 to 80 degrees Fahrenheit (°F), approximate nighttime temperatures of 50 to 55 °F, and wind speeds of approximately 10 to 15 miles per hour. Terrestrial habitats were delineated and the dominant vegetation identified. Habitat types identified for OU-2 sites are shown in Figure 2-17. The literature sources used to identify terrestrial plant species during the site reconnaissance included *The Jepson Manual* (Hickman 1993), *Manual of Flowering Plants of California* (Jepson 1925), *Terrestrial Vegetation of California* (Barbour 1988), *A Field Guide to Pacific States Wildflowers* (Niehaus and Ripper 1976), and "The Grower's Weed Identification Handbook" (University of California 1988). The literature sources used to identify terrestrial animal species included *Field Guide to Birds of North America* (National Geographic Society [NGS] 1987); *Mammals of the Pacific States: California, Oregon, Washington* (Ingles 1965); and *Animal Tracks* (Murie 1974). The results of the plant and animal surveys completed for the OU-2 sites are summarized in Table 5-5.

5.2.2 Exposure Pathways

Both existing and potential exposure pathways were identified for terrestrial and surface water (marine) receptors. Potential terrestrial exposure pathways to contaminated soil include direct contact, incidental ingestion, volatilization and wind-blown dust, and food-chain effects. As requested by EPA and DTSC, the ERA assumes that all existing buildings and pavement at OU-2 are removed and that the underlying soil immediately provides suitable habitat for higher trophic level receptors.

Surface water exposure is addressed by quantifying the potential for contaminated groundwater to reach the Seaplane lagoon and other waters of San Francisco Bay primarily through utility trenches such as the

storm water sewers. As discussed previously, the storm sewers have undergone extensive renovation, including a removal action for contaminated sediment.

Potential exposure pathways were evaluated for OU-2 based on the potential fate and transport of each ecological COPC and the movement of ecological COPCs through the food web postulated to exist at the site. These complete exposure pathways were identified prior to a quantitative evaluation of toxicity to allow the assessment to focus on only contaminants that can reach ecological receptors. For an exposure pathway to be considered complete, an ecological COPC must be able to travel from the source to ecological receptors and to be taken up by the receptors through one or more exposure routes.

To evaluate each potential exposure pathway, an ecological conceptual site model (CSM) was developed that graphically represents the potential movement of the COPCs through the environment. The ecological CSM for OU-2 is presented in Figure 5-4. Evaluation of the ecological CSM indicates that complete exposure pathways under the fully exposed soil scenario include direct contact with chemicals in soil, ingestion of airborne particles and vapors, direct contact with groundwater where it discharges into San Francisco Bay, and indirect contact through food-chain exposure. The discussion below summarizes each potential exposure pathway under this scenario.

Direct Exposure to Soil. Plants and animals in contact with the soil at OU-2 can be directly exposed to PAHs, pesticides, PCBs, metals, VOCs, and SVOCs through ingestion, dermal exposure, and uptake by plants. Direct exposure is expected to involve all trophic levels. Therefore, direct exposure to soil at OU-2 is a complete exposure pathway under the fully exposed soil scenario. In addition to the potential direct effects to receptors, contaminated soil at OU-2 is a source of ecological COPCs to the underlying groundwater.

Direct Exposure to Surface Water. Precipitation and runoff at OU-2 is contained and managed within an extensive storm sewer system that is the subject of a separate investigation. Precipitation and runoff also infiltrates soil to groundwater. Groundwater and storm sewers ultimately discharge to San Francisco Bay. Therefore, the surface water pathway is considered a complete pathway for OU-2 based on potential water quality impacts to San Francisco Bay.

Direct Exposure to Air. Many of the ecological COPCs associated with OU-2 have extremely low volatilization rates. Ecological COPCs with low volatilization rates include metals (except mercury), PAHs, PCBs, insecticides, and SVOCs. The exceptions are VOCs generally detected at low levels in soil.

Minimal volatilization from ecological COPCs from soil to the air is expected. Windblown dust could represent a complete exposure pathway because exposed soil is assumed to exist at OU-2. Therefore, the air exposure pathway is considered to be a completed exposure pathway primarily resulting from airborne dust ingestion at OU-2 under the fully exposed soil scenario. This exposure pathway, although complete, is postulated to be insignificant compared to food-chain transfer and direct soil exposure.

Food Chain Exposure. A number of the ecological COPCs associated with OU-2 have the potential to bioaccumulate and biomagnify in the food chain, including PCBs, chlorinated pesticides, and dioxins and furans. A number of higher trophic level receptors could be exposed to ecological COPCs through diet. Therefore, food-chain exposure is a complete exposure pathway under the fully exposed soil scenario.

5.2.3 Identification of Ecological Chemicals of Potential Concern

Ecological COPCs are organic and inorganic chemicals that are potentially site-related and that have the potential for causing adverse effects to ecological receptors. Existing soil and groundwater data were used to develop ecological COPCs for each site in OU-2. Soil data were analyzed for soil at 0 to 6 feet bgs, which represents the maximum burrowing depth of the California ground squirrel. Groundwater data represent both HydroPunch® and monitoring well data from 1994 through 1998 in the FWBZ. The use of older HydroPunch® data may not be representative of current groundwater conditions. However, these data provide some of the highest groundwater concentrations and thus represent an upperbound or worst-case condition.

The following sections discuss the identification of ecological COPCs in soil (Section 5.2.3.1) and groundwater (Section 5.2.3.2).

5.2.3.1 Identification of Ecological Chemicals of Potential Concern in Soil

The process for selecting soil ecological COPCs at OU-2 is shown in Figure 5-5. All detected and identified compounds were screened using the process shown in the flow chart. One-half of the SQL was used as a proxy value for nondetected results when calculating descriptive statistics (that is, the mean, 95 UCL, and standard deviation values). The lower of the 95 UCL or maximum detected value was used as the basis for the screenings used to identify ecological COPCs. The distribution of each chemical (that is, normal or lognormal) was taken into account when quantifying 95 UCLs. When a distribution could not be determined, maximum detected values were used.

Similar to the approach used for the HHRA, ecological PRGs were used during the COPC screening process. Ecological PRGs for soil were developed by the Oak Ridge National Laboratory (ORNL) (Efroymson and others 1997) by comparing toxicological benchmarks for wildlife, plants, and soil invertebrates (earthworms). The lowest value available is used as the PRG.

Chemicals detected in the 0- to 6-foot-bgs soil column interval were screened or retained as ecological COPCs based on the criteria summarized below:

- A frequency of detection criterion was used because chemicals detected infrequently may be considered as sampling and analytical artifacts or spurious data (EPA 1989b). Chemicals with a frequency of detection of less than 5 percent were eliminated if there was no reason to believe that the chemicals would be present because of site-related activities. All detected chemicals were also evaluated for historical site use; concentration; and potential toxicity, mobility, persistence, and bioaccumulation. For example, the frequency of detection screen was not applied to bioaccumulative compounds such as chlorinated pesticides and mercury. Chemicals with a frequency of detection greater than 5 percent were then compared to ecological PRGs and the other criteria was described below.

- Ecological PRGs developed by ORNL (Efroymson and others 1997) are based on minimal soil concentrations corresponding to adverse effects on the general ecological assessment endpoints. PRGs were selected based on toxicological benchmarks for wildlife, plants, and soil invertebrates (earthworms). The lowest soil concentration corresponding to an acceptable level (or minimal adverse effect level) was selected as the ecological soil PRG. Chemicals were eliminated as ecological COPCs if they were detected at a low frequency or their maximum concentrations were below their ecological soil PRG values. The exception was that the PRG screening was not applied to bioaccumulative compounds such as chlorinated pesticides and mercury. Chemicals with concentrations exceeding ecological PRG values were retained. Chemicals with no existing PRG values were also retained as ecological COPCs.

- Inorganics identified as essential nutrients, such as calcium, iron, magnesium, potassium, and sodium, were not retained as ecological COPCs. Because of their common occurrence and very high doses required for toxic effects, TRVs for these chemicals have not been developed.

- Inorganics exceeding area-specific background (and any applicable PRGs) were retained as ecological COPCs. Additional information on the use of site- and area-specific background is discussed below.

The comparison between the site-specific background data and the site-specific data consists of a tool box approach that includes a "hot spot" comparison, as well as parametric and nonparametric tests of means for inorganic chemicals at a significance level of 0.95 (alpha = 0.05) and power of 0.90 (beta = 0.10).

Figure 5-2 presents a flowchart outlining the statistical toolbox approach used for Alameda Point. The 80 LCL/95 was calculated for each inorganic analyte in the site-specific background data set. If the calculated maximum detected concentration exceeded the 80 LCL/95 for a chemical, the 80 LCL/95 value was used for the comparison. The 95 UCL concentration was calculated for each of the chemicals detected at each site based on its distribution. The maximum detected concentration or the 95 UCL concentration, whichever was lower for each inorganic chemical at each site, was compared to the 80 LCL/95 concentration of the site-specific background data. The results of this comparison, together with the results of the statistical tests of means, were used to determine whether an inorganic chemical exceeded the site-specific background concentration. Inorganics that exceeded the site-specific background concentrations were compared to the lowest available ecological soil PRGs, which are based on the most sensitive receptor group tested, to determine if a chemical was an ecological COPC. The results of the ecological COPC selection process for each site in OU-2 are summarized in Chapters 6 through 10 for the OU-2 Southeastern, Eastern, and Central areas, and for IR Sites 14 and 25, respectively. Tables presented in these chapters list ecological COPCs for soil at the 0- to 6-foot-bgs depth interval.

Site-specific background concentrations for metals are shown in Tables 2-2b and 2-2c. The pink area depicted in Figure 2-19 corresponds to area-specific background concentrations for fill area 1. These area-specific background concentrations were used for Sites 3, 11, and 21 in the Eastern area; Sites 5, 10, and 12 in the Central area; and IR Sites 14 and 25. The blue area depicted in Figure 2-19 corresponds to area-specific background concentrations for fill area 2. These area-specific background concentrations were used for Sites 9, 13, 19, 22, and 23 in the Southeastern area and Site 4 in the Eastern area.

5.2.3.2 Identification of Ecological Chemicals of Potential Concern in Groundwater

The process for selecting groundwater ecological COPCs at OU-2 is shown in Figure 5-5. All detected and identified compounds were screened using the process shown in the flow chart. One-half of the SQL was used as a proxy value for nondetected results to calculate descriptive statistics (that is, mean, 95 UCL, and standard deviation values). The lower of the 95 UCL or maximum detected value was used as the basis for the screenings used to identify ecological COPCs. The distribution of each chemical (that is, normal or lognormal) was taken into account when quantifying 95 UCLs. When a distribution could not be determined, maximum detected values were used. Chemicals detected in HydroPunch® or monitoring well samples were screened or retained as ecological COPCs based on the criteria summarized below.

- A frequency of detection criterion was used because chemicals detected infrequently may be considered as sampling and analytical artifacts or spurious data (EPA 1989b). Chemicals with a frequency of detection of less than 5 percent were eliminated if there was no reason to believe that the chemicals would be present because of site-related activities. All detected chemicals were also evaluated for historical site use; concentration; and potential toxicity, mobility, persistence, and bioaccumulation. For example, the frequency of detection screen was not applied to bioaccumualtive compounds such as chlorinated pesticides and mercury. Chemicals with a frequency of detection greater than 5 percent were then compared to water quality criteria developed by EPA for chronic effects in marine waters.

- Inorganics exceeding area-specific background (and any applicable criterion continuous concentrations [CCC]; see below) were retained as ecological COPCs.

- Water quality criteria issued pursuant to the Clean Water Act, Section 304a, were used to identify groundwater ecological COPCs based on the groundwater to surface water exposure pathway. According to the Clean Water Act, water quality criteria are intended to accurately reflect the latest scientific knowledge of the effects of many chemicals on aquatic and marine life. Water quality criteria are used by EPA, states, and other organizations to determine acceptable concentrations of chemicals introduced into fresh water and marine ecosystems. For OU-2, chemicals exceeding EPA's CCC for salt water were retained as ecological COPCs (EPA 1999a). The CCC is an estimate of the highest concentration of a chemical in surface water to which an aquatic community can be exposed indefinitely without resulting in unacceptable effects.

- Chemicals for which the maximum concentration detected was less than the CCC for salt water were not retained as ecological COPCs.

- The National Oceanographic and Atmospheric Administration (NOAA) has stated that it is its practice to use a dilution factor of 10 to compare chemical concentrations in groundwater to water quality criteria (NOAA 1999). (An alternative approach would be to calculate a site-specific dilution factor.) Based on NOAA's practice, chemicals with maximum groundwater concentrations exceeding water quality criteria were divided by a factor of 10 to account for dilution. This diluted value was then compared to the CCC for salt water. Chemicals for which the maximum concentration divided by 10 was less than the CCC for salt water were not retained as ecological COPCs.

- For chemicals that exceeded the water quality criteria, 95 UCLs were calculated based on a 10-fold dilution of the maximum concentration. The 95 UCL concentration was divided by 10 to account for dilution consistent with NOAA's practice. Chemicals for which the 95 UCL concentration divided by 10 was less than the CCC for salt water were not retained as ecological COPCs.

- Inorganics identified as essential nutrients, such as calcium, iron, magnesium, potassium, and sodium, were not retained as ecological COPCs. Because of their common occurrence and very high doses required for toxic effects, TRVs for these chemicals have not been developed.

Identification of groundwater ecological COPCs, and subsequent groundwater fate and transport modeling are used to identify chemicals requiring analysis in future sampling of the storm sewer system associated with OU-2. Model inputs are based on the maximum concentrations detected at OU-2. The storm sewer ditches are assumed to provide the most direct conduit for contaminant transport.

5.2.4 Assessment and Measurement Endpoints

Assessment and measurement endpoints were developed for OU-2 as part of step 3, problem formulation, as explained by EPA (1997c). Assessment endpoints are defined as environmental values (for example, ecological resources) to be protected. Assessment endpoints frequently relate to statutory mandates. However, assessment endpoints should define the valued ecological entity at the site (such as species, ecological resource, or habitat type) and a characteristic of the entity to protect (such as reproductive success). Measurement endpoints are measurable biological responses to a stressor that can be related to the valued characteristic chosen as the assessment endpoint. In general, measurement endpoints include both measures of effect and of exposure. An example of a measurement endpoint would be potential reproductive or physiological impacts to a specific receptor.

The following sections discuss the identification of assessment endpoints (Section 5.2.4.1) and measurement endpoint (Section 5.2.4.2).

5.2.4.1 Assessment Endpoints

In general, OU-2 consists of developed and paved areas within Alameda Point. Suitable wildlife habitats are limited; however, this screening-level ERA assumes that all pavement is removed and that soil is exposed. Ecological COPCs identified at OU-2 produce different effects on different trophic levels; therefore, assessment endpoints representing two different trophic levels were developed. The paragraphs below summarize the assessment endpoints selected for evaluation of ecological risk at OU-2, along with a discussion of the rationale.

- **Sufficient Rates of Survival, Growth, and Reproduction to Sustain Small Mammal Populations Typical to the Area** - A number of studies have shown that the ecological COPCs associated with OU-2 can cause reproductive impairment; reduced growth; altered behavior; various physiological effects; mortality; and mutagenic, teratogenic, and other effects on mammals (Peterle 1991; EPA 1975); Eisler 1986; Amdur and others 1991; Eisler 1988; Wong and others 1978; Brancia and Konrad 1980; Settle and

Patterson 1980 as cited in Eisler 1988). Small mammals such as the California ground squirrel and various voles are secondary consumers that provide a major food source for upper trophic level consumers such as raptors and mammalian carnivores. Effects on the potential small mammal community of OU-2 could result in a reduction of food available to upper trophic level carnivores and corresponding reductions to populations of these upper trophic level organisms. Therefore, the small mammal community is an ecological value to be considered for protection.

- **Sufficient Rates of Survival, Growth, and Reproduction to Sustain Raptor Populations Typical to the Area** – Literature data indicate that the COPECs associated with OU-2 can potentially cause reproductive impairment, reduced growth, altered behavior, various physiological effects, mortality, teratogenic, and other effects on birds (Beyer and Others 1996; Peterle 1991; EPA 1995b; Hoffman and Others 1996). The raptors are the major tertiary consumers at the site and are strongly susceptible to the effects of bioaccumulating COPECs. Effects on the raptor population of Alameda would be undesirable because of the effects that the loss of predation would have on the lower trophic levels. Therefore, the raptor population is an ecological value to be considered for protection.

5.2.4.2 Measurement Endpoints

The measurement endpoints described below were selected based on ecotoxicity data for the ecological COPCs found at OU-2 and the assessment endpoints previously defined. Each measurement endpoint is based on species or communities present or potentially present at OU-2, is amenable to evaluation based on literature research, and can be used to infer information about the related assessment endpoint. The measurement endpoints summarized below were at OU-2.

- **Reproductive or Physiological Impacts to the California Ground Squirrel** - The California ground squirrel (*Citellus beecheyi*) was used as a surrogate to represent the small mammal population associated with the site. Potential reproductive or physiological impacts were evaluated against the TRVs developed by the Navy (1998) or ecological reference values from ORNL (Sample and others 1996). For ecological COPCs that did not have an existing TRV or ERV, a qualitative evaluation was performed. A conservative daily dose was calculated based on site ecological COPC concentrations and natural history information on the California ground squirrel (Linsdale 1946). HQs were developed by dividing the daily dose by the appropriate TRV for each ecological COPC. HQs greater than 1.0 indicate the potential for unacceptable risks to the measurement endpoint.

- **Reproductive or Physiological Impacts to the Red-Tailed Hawk** - The red-tailed hawk (*Buteo jamaicensis*) was used as a surrogate to represent the raptor population associated with the site. Potential reproductive or physiological impacts were evaluated against the TRVs developed by the Navy (1998) or ERVs from ORNL (Sample and others 1996). For ecological COPCs that did not have an existing TRV or ERV, a qualitative evaluation was performed. A conservative daily dose was calculated based on site ecological COPC concentrations and natural history information on the red-tailed hawk (EPA 1993c). HQs

were developed by dividing the daily dose by the appropriate TRV for each ecological COPC. HQs greater than 1.0 indicate the potential for unacceptable risks to the measurement endpoint.

5.2.5 Ecological Effects Evaluation

This section provides exposure estimates and the risk evaluation, including development of TRVs and HQs. Exposures of each measurement endpoint (California ground squirrel and the red-tailed hawk) to each ecological COPC were conservatively estimated based on organism life history, site contaminant concentrations, and other data. This exposure information was then compared with the relevant TRVs to develop a quantitative evaluation of the potential risk to ecological receptors. As stated above, HQ values greater than 1.0 indicate the potential for unacceptable risks to ecological receptors. TRVs and HQs for ecological COPCs in soil were developed based on the information provided in Section 5.2.5.1. For OU-2 groundwater, HQs were developed based on water quality criteria as explained in Section 5.2.5.2.

The following sections discuss the development of TRVs (Section 5.2.5.1), exposure estimates (Section 5.2.5.2), risk evaluation and calculation for COPCs in soil (Section 5.2.5.3), and risk calculations for groundwater (Section 5.2.5.4).

5.2.5.1 Development of TRVs for Soil

A TRV or ERV is a daily dose level at which a particular biological effect may occur in an organism based on laboratory toxicological investigations. TRVs for avians and mammals were developed by the Navy (Navy 1998) for 20 chemicals found at Navy installations in the San Francisco Bay area. These chemicals include 11 metals (arsenic, cadmium, cobalt, copper, mercury, lead, manganese, nickel, selenium, thallium, and zinc); butylin, five pesticides (aldrin, DDT, heptachlor, lindane, and methoxychlor); PCBs; and 2 PAHs (benzo[a]pyrene and naphthalene). High and low TRVs were developed based on the variability of ERA parameters. High TRVs are associated with the minimal dose at which an adverse effect is expected. Low TRVs are associated with the dose at which no adverse effects are observed. The TRVs were developed by the Navy in consultation with the EPA Region IX BTAG. The BTAG includes representatives of the Navy, EPA, NOAA, USFWS, DTSC, California Department of Fish and Game, and RWQCB. The high and low TRV values were reviewed and agreed on by the BTAG.

Additional ERVs were developed based on toxicological information provided by ORNL (Sample and others 1996) and methods used by the Navy as summarized earlier in Section 5.2.4.2. ORNL reports provide toxicological benchmarks for wildlife based on data and information available from EPA, USFWS, and peer-reviewed journals. The ORNL toxicological benchmark report (Sample and others 1996) provides data on "no observed adverse effects levels" (NOAEL) and "lowest observed adverse effects levels" (LOAEL) for 85 chemicals as applied to 9 mammalian species and 11 avian wildlife species. In some cases, the studies provide only NOAEL concentrations used as the low TRVs. In these cases, the high ERV was assumed to be 10 times the low ERV.

5.2.5.2 Exposure Estimates

Exposure assumptions related to small mammal endpoints are summarized below.

- Soil data from the 0- to 6-foot-bgs interval were used in the development of doses (in mg/kg-day) of ecological COPCs to the small mammal's food source. The lower of the 95 UCL or maximum detected value was used to develop the exposure point concentration (EPC) to the food source.

- Small mammals were assumed to have a diet consisting of earthworms and plants. The EPC was determined to be a modeled concentration in the earthworms and plants derived by multiplying the soil concentration by the appropriate conservative biotransfer factors (BTF).

- The EPC was converted to a dose in mg/kg-day to the California ground squirrel for each ecological COPC by using appropriate natural history information on ingestion rates and body weights. The dose was then divided by the appropriate TRV for each ecological COPC to develop HQs for the selected endpoint and HQ scenario. The detailed calculations are presented in Appendix N.

- Trophic transfer coefficients (TTC) and site use factors (SUF) were incorporated into the daily dose estimates. Low, high, and typical daily dose estimates were calculated by varying the values of exposure parameters such as ingestion rate and body weight. The values used for exposure assessment are presented in Appendix N.

The following general equation was used to calculate dose for the California ground squirrel:

$$\text{Dose} = \frac{[([\text{Soil}] \times \text{Soil IR}) + ([\text{Plant}] \times \text{Plant IR}) + ([\text{Invert}] \times \text{Invert IR})] \times \text{TTC} \times \text{SUF}}{\text{BW}}$$

Where

Soil	=	Soil concentration
Plant	=	Plant concentration; [Soil] x Soil: Plant BTF
Invert	=	Invertebrate concentration; [Soil] x soil: Invertebrate BTF
IR	=	Receptor ingestion rate
TTC	=	Trophic transfer coefficient
SUF	=	Site use factor
BW	=	Body weight

Exposure assumptions related to raptor endpoints are summarized below.

- Raptors at the site were assumed to have a diet consisting exclusively of the California ground squirrel. The EPC was determined to be a modeled concentration in the California ground squirrel derived by multiplying the daily dose by the squirrel's average age in the field (180 days) for bioaccumulating ecological COPCs (including PCBs, chlorinated pesticides, dioxins and furans, and mercury). For ecological COPCs that the literature indicates do not significantly bioaccumulate, the EPC was assumed to be the daily dose ingested by the squirrel.

- The EPC was converted to a dose in mg/kg-day by using natural history information on ingestion rates and body weights for the red-tailed hawk. The dose was then divided by the appropriate TRV for each ecological COPC to develop HQs for the selected endpoint and HQ scenario. The detailed calculations are presented in Appendix N.

- TTC and SUFs were incorporated into the daily dose estimates. Low, high, and typical daily dose estimates were calculated for each receptor by varying the values of exposure parameters such as ingestion rate and body weight. The values used for exposure assessment are presented in Appendix N.

The dose equation for calculating doses to the red-tailed hawk is as follows:

$$\text{Dose} = \frac{[([\text{Soil}] \times \text{Soil IR}) + ([\text{Vert}] \times \text{Vert IR})] \times \text{TTC} \times \text{SUF}}{\text{BW}}$$

Where

$$TRV_{cgs} = (TRV_{literature\text{-}based})(Body\ Weight_{cgs}[kg]/Body\ Weight_{literature\text{-}based}[kg])^{1/4}$$

Soil	=	Soil concentration
Vert	=	Vertebrate concentrations
IR	=	Receptor ingestion rate
TTC	=	Trophic transfer coefficient
SUF	=	Site use factor
BW	=	Body weight

Laboratory-derived TRVs were allometrically converted to receptor-specific TRVs for the California ground squirrel using the following BTAG-recommended equation (Navy 1998):

$$TRV_{cgs} = (TRV_{literature\text{-}based})(Body\ Weight_{cgs}[kg]/Body\ Weight_{literature\text{-}based}[kg])^{1/4}$$

As recommended in the Navy TRV guidance (Navy 1998), no allometric conversions were performed for avian TRVs.

5.2.5.3 Risk Evaluation and Risk Calculations for COPCs in Soil

The risk calculations were prepared for the California ground squirrel and red-tailed hawk based on the exposure assumptions for the individual endpoint. The risk calculations were conducted as described in Appendix N.

The paragraphs below describe the risk evaluation process and development of HQs for the California ground squirrel.

- No specific TRVs or ERVs are identified for the PAH ecological COPCs acenaphthylene, anthracene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, carbozole, chrysene, dibenzo(a,h)anthracene, fluoranthene, ideno(1,2,3-cd)pyrene, phenanthrene, and pyrene. However, a specific TRV is available for mammals for benzo(a)pyrene. Benzo(a)pyrene is usually considered the most toxic of the PAH compounds. The PAH compounds were therefore evaluated for potential effects on the California ground squirrel based on the TRV for benzo(a)pyrene.

- The calculations for polychlorinated-p-dioxin (PCDD) and polychlorinated dibenzofuran (PCDF) congeners are based on the appropriate 2,3,7,8 tetratchlorodibenzo-p-dioxin (TCDD) toxicity equivalents. Toxicity equivalents for PCDD and PCDF congeners are presented in Appendix N.

- The calculations for Aroclor-1260 were based on the TRV for Aroclor-1254. No TRV for Aroclor-1260 was identified.

The paragraphs below describe the risk evaluation process and development of HQs for the red-tailed hawk.

- Literature data were inadequate to develop ERVs for some of the chlorinated pesticides. To support the screening-level ERA, the TRV for 4,4'-DDT was used to evaluate the potential effects of other chlorinated pesticides (such as endosulfan sulfate and heptachlor epoxide) when specific ERVs were not available.

- Literature data were inadequate to develop ERVs for the red-tailed hawk for any of the PAH ecological COPCs.

- The calculations for PCDD and PCDF congeners are based on the appropriate TCDD toxicity equivalents. Toxicity equivalents for PCDD and PCDF congeners are presented in Appendix N.

- The calculations for mercury are based on the TRV for methyl mercury.

- The calculations for Aroclor-1260 were based on the TRV for Aroclor-1254. No TRV for Aroclor-1260 was identified.

Daily dose estimates were compared to allometrically converted TRVs or ERVs (PRC 1995a) for the California ground squirrel and unconverted TRVs or ERVs for avian receptors to estimate potential risks to each receptor. The daily dose (in mg/kg-day) was divided by the TRV to obtain the HQ. HQs exceeding 1.0 indicate the potential for adverse effects. Five HQs were calculated to encompass the theoretical range of risk estimates based on the range of biological and toxicological data published in available peer-reviewed literature. HQ_1 compares a low daily dose estimate to a high TRV. HQ_2 and HQ_3 compare a high daily dose estimate to a low and high TRV, respectively. HQ_4 and HQ_5 compare "typical" or average daily dose estimates to low and high TRVs, respectively. Conservative assumptions employed during the estimation of the HQ_2 include but are not limited to the following:

- High end estimate of a receptor's total daily ingestion rate
- Low end estimate of a receptor's body weight
- Assumptions of 100 percent bioavailability and no depuration, which are reflected by the TTC being set equal to 1

For the red-tailed hawk, the two conservative assumptions below were used to calculate HQ_2.

- California ground squirrels make up 100 percent of the hawk's vertebrate on-site prey.
- The California ground squirrel's exposure duration equals 180 days (the average age of a California ground squirrel in the field), which also reflects the assumptions of 100 percent bioavailability and no depuration.

Assumptions employed for estimating the HQ_1 were conservative but employ a shorter exposure duration and only partial bioavailability and absorption of ingested chemicals.

Calculation of HQ_4 and HQ_5 incorporate average dose estimates of the following parameters:

- Average of receptor's high and low total daily ingestion rate
- Average of receptor's high and low body weight

The exposure assumptions for each HQ scenario are presented in Appendix N.

5.2.5.4 Risk Calculations for Groundwater

Chemicals detected in groundwater that were retained as ecological COPCs (based on the screens described in Section 5.2.3.2) were then compared to additional water quality criteria. These additional water quality criteria include the following:

- Water quality criteria for chronic effects in salt water developed by the State of Washington.
- EPA's 1997 water quality criteria for California waters, known as the "California Toxics Rule."
- RWQCB San Francisco Basin Plan Water Quality Objectives (RWQCB 1995).

- EPA's ambient water quality criteria for acute salt water or chronic freshwater.

- Tier II chronic values developed by ORNL were only used for chemicals lacking water quality criteria developed by EPA or state agencies (Sample and others 1996) and are considered to have a higher uncertainty associated with their use since they are derived for freshwater systems. The Tier II values were developed by ORNL using the method described by EPA (1993) in setting water quality guidance for the Great Lakes. The Tier II method allows aquatic benchmarks to be established with fewer data than are required for ambient water quality criteria (AWQC). The Tier II values are concentrations that would be expected to be higher than AWQC with a frequency of no greater than 20 percent. The Tier II values are also referred to secondary chronic values (SCV).

The appropriate water quality criteria or SCV was used as the equivalent of a TRV for marine life. The HQ was derived by dividing the monitored or modeled groundwater concentration by the appropriate water quality criteria or SCV. HQs with values greater than 1.0 indicated the potential for adverse effects to marine life.

5.2.6 Presenting Results of the Screening-Level ERA

Each site within OU-2 was evaluated against the criteria presented in Sections 5.2.1 through 5.2.5. This evaluation included quantifying potential risks from ecological COPCs in soil to the California ground squirrel and the red-tailed hawk. Soil data were evaluated from the 0-to 6-foot-bgs depth interval, and ecological COPCs were identified using the process described in Section 5.2.3.1. Potential risks for each site were quantified as HQ_1 through HQ_5 as described in Section 5.2.5 and Appendix N. Calculated HQs for physiological and reproductive effects for the HQ_1, HQ_2, HQ_3, HQ_4, and HQ_5 scenarios for the California ground squirrel and the red-tailed hawk are presented in separate tables in Chapters 6 through 10. Based on the developed nature and urban setting of OU-2, it was determined that HQ_5 is most representative of site conditions and represents the most appropriate set of criteria for evaluating potential risks to ecological receptors. HQ_5 values for ecological COPCs whose HQs exceed 1.0 are discussed and summarized for each site within OU-2. The discussion for each site also addresses uncertainties that affect potential risks to ecological receptors.

Potential risks from the groundwater to surface water pathway were evaluated based on exceedances of water quality criteria and proximity to storm sewers that would allow transport to San Francisco Bay. Because the storm sewers are the primary transport mechanism for groundwater ecological COPCs to surface water, all wells and HydroPunch® locations within 50 feet of the storm sewers were identified and evaluated to determine if the ecological COPCs had been detected at those locations. The

concentrations of ecological COPCs in the wells were then screened against the TRVs or ERVs to identify locations where ecological COPCs could potentially enter the storm sewer at concentrations representing a potential risk to ecological receptors. The wells and sampling locations within 50 feet of a storm sewer and the results of the screening are presented in tables grouped by Southeastern, Eastern, and Central areas. Results of this evaluation will be used to develop and prioritize sampling and analysis of the storm sewer system.

5.3 FATE AND TRANSPORT MODELING

Fate and transport modeling was conducted to support evaluation of future risk to human and ecological receptors exposed to groundwater contaminated by OU-2 sites. The primary concern for human health risk is migration of COCs to the waters of the San Francisco Bay. Fate and transport modeling was used to predict the concentrations of human health COCs after 20 and 100 years. The modeling approach includes several conservative, simplifying assumptions to provide a "worst case" estimate of the extent and magnitude of chemical migration. An example HHRA COC, benzene, is used in the discussion below and in Sections 5.3.1 through 5.3.4 to illustrate the use of model input parameters and equations to predict the migration of this COC in the OU-2 Southeastern area.

For the HHRA, the general objective of the fate and transport modeling is to estimate the downgradient extent of the human health COC plume within a 20- and 100-year time period. The downgradient extent is defined by sampling locations at which the COC concentration exceeds a regulatory threshold such as an MCL.

For the ERA, the general objective of the fate and transport modeling is to predict the maximum contaminant concentration of each ecological COPC reaching the nearest storm sewer within a 20- and 100-year time period.

The following sections describe the (1) conceptual site model used to provide the framework of the modeling effort, (2) contaminant fate and transport model selection, (3) model input parameter estimation, and (4) modeling results and uncertainties.

5.3.1 Conceptual Site Model

Based on a preliminary review of site data and considering the objectives outlined above, the groundwater flow and contaminant transport conditions at OU-2 are summarized below.

- Groundwater flow is horizontal and occurs primarily in the more permeable fill and native sediments.
- Groundwater flow is uniform between the suspected source areas and the potential receptor locations, including the utilities.
- Sources of COPCs are located within regions of higher relative soil and groundwater COPC concentrations.
- Sources of releases of COPCs to groundwater are decaying over time.
- Chemicals in groundwater may migrate by groundwater advection along one direction.
- Chemicals may migrate by dispersion in one or two directions.
- Dissolved chemicals may adsorb to soil solids.
- Dissolved chemicals that are readily degradable may transform into chemicals that are not of concern.

5.3.2 Model Selection

EPA's Natural Attenuation Decision Support System, "BIOSCREEN" (Newell and others 1996), was used to perform analytical contaminant fate and transport modeling for the OU-2 sites. The BIOSCREEN program simulates contaminant transport in the dissolved phase when no active remedial measures are applied. The program is based on the Domenico (1987) three-dimensional analytical solute transport model (see Appendix J). The original model assumes a fully penetrating vertical plane source oriented perpendicular to groundwater flow direction to simulate the release of contaminants to moving groundwater. In addition, the Domenico solution accounts for the effects of advective transport, three-dimensional dispersion, adsorption, and first-order decay (Newell and others 1996).

In BIOSCREEN, the Domenico solution has been adapted to provide three different options representing the following transformation processes:

- Contaminant transport with no decay
- Contaminant transport with first-order decay
- Contaminant transport with "instantaneous" biodegradation reaction

The contaminant transport with no decay scenario was used to provide conservative modeling of contaminants that are recalcitrant in natural groundwater systems (such as halogenated hydrocarbons) and inorganic elements. For readily degradable chemicals, such as petroleum hydrocarbons, first-order decay was used to simulate transformation in groundwater. Contaminant transport with the instantaneous biodegradation reaction was not used in contaminant fate and transport modeling.

The key assumptions in the model are summarized below.

- The aquifer and flow field are homgenenous and istropic.
- Groundwater velocity is fast enough that molecular diffusion in the dispersion terms can be ignored (may not be appropriate for simulation of transport through clay).
- Adsorption is a reversible process represented by a linear isotherm.

The most important modifications to the original Domenico model are summarized below.

- The addition of "layer cake" source terms where three Domenico models are superimposed one on top of another to yield the five source terms used in BIOSCREEN.
- Addition of the instantaneous reaction term using the superposition algorithm; for the instantaneous reaction assumption the source concentration is assumed to be an "effective source concentration" equal to the observed concentration in the source zone plus the biodegradation capacity (see "Source Zone concentration" in the BIOSCREEN Source Data section).

The key limitations of the BIOSCREEN model are summarized below (Newell and others 1996).

- The model should not be applied where pumping systems create a complicated flow field. No groundwater pumping is specified in the contaminant transport model.
- The model should not be applied where vertical flow gradients significantly affect contaminant transport. Only contaminant transport in the FWBZ will be simulated. Vertical dispersivity will be set equal to zero.

- The model should not be applied where hydrogeologic conditions change dramatically over the simulation domain. For modeling purposes, isotropic and homogenous hydrogeologic conditions will be assumed to prevail over each entire OU-2 area.

5.3.3 Model Input Parameter Estimation

The major parameters required by the model are described below. In addition, Appendix J includes model input and output printouts. The model input and output are divided into the following major sections:

- Section 1, Hydorgeology
- Section 2, Dispersion
- Section 3, Adsorption
- Section 4, Biodegradation
- Section 5, General
- Section 6, Source Data
- Section 7, Field Data for Comparison
- Section 8, Output
- Unnumbered, Dissolved Chemical Concentrations in Plume

The input parameters for the OU-2 Southeastern, Eastern, and Central areas and for IR Sites 14 and 25 are described in Chapters 6 through 10, respectively and are briefly summarized below.

Section 1, Hydrogeology

Groundwater Flow Velocity (v)

Groundwater flow velocity was calculated by Section 1 of the BIOSCREEN model using the following equation:

$$v = \frac{K\ dh}{n\ dl}$$

where

v	=	Groundwater flow velocity
K	=	Hydraulic conductivity
n	=	Porosity (percent)
$\frac{dh}{dl}$	=	Hydraulic gradient (unitless)

Groundwater flow velocity and its input parameters were assumed to be constant for each area. For the Southeastern area, the model calculated groundwater velocity to be 37 feet per year using the input variables described below and summarized in Appendix J.

Hydraulic Conductivity (K)

Values for the input parameter K were taken from the results of various aquifer tests performed at OU-2 sites. For sites where no aquifer tests were conducted, a value for K was assumed based on lithology and average values observed at other OU-2 sites. The aquifer properties used for contaminant transport modeling are shown in the figures in Chapters 6 through 10. Based on these values, an average value for K was calculated for each OU area. For the Southeastern area, the hydraulic conductivity was 5 feet per day or 1.7×10^{-3} centimeters per second (cm/s) (see Appendix J).

Effective Porosity (n)

A constant effective porosity of 25 percent was used for all OU-2 areas. This value is representative of the sand clay unit that composes the aquifer material encountered in the FWBZ (Freeze and Cherry 1979).

Hydraulic gradient (dh/dl)

Measured hydraulic gradient values at each site were used to calculate an average value for each OU-2 area. For sites where no measured values exist, an assumed value consistent with measured values at other sites was used. For the Southeastern area, the hydraulic gradient was 0.005 (see Appendix J.).

Section 2, Dispersion

Dispersivity (α_x and α_y)

Dispersivity (longitudinal and transverse) was calculated by Section 2 of the BIOSCREEN model using the following equations (Xu and Eckstein 1995):

$$\alpha_x = 3.28x0.83\,[\log_{10}(\frac{L_p}{3.28})]^{2.414}$$

where

α_x = Longitudinal dispersivity (feet)
L_p = Plume Length (feet)

Where

α_y = Transverse dispersivity (feet)

and

$$\alpha_y = 0.1 \times \alpha_x$$

Plume Length (L_p)

The input parameter of L_p was set equal to the distance over which contaminant migration was simulated. This is a conservative assumption because it will provide an upper-bound estimate for longitudinal and transverse dispersivity.

For the HHRA, plume length was set equal to the distance from the source to the nearest surface water body. For the HHRA COC benzene in the OU-2 Southeastern area, the estimated plume length was 1,125 feet.

Section 3, Adsorption

Retardation Factor (R)

Retardation factor was calculated by Section 3 of the BIOSCREEN model using the following equation:

$$R = 1 + \frac{K_d \rho_b}{n}$$

where

R	=	Retardation cantor (unitless)
K_d	=	Distribution coefficient (unit)
ρ_b	=	Solid bulk density (kilogram per liter [kg/L])
n	=	Porosity (percent)

and

$$K_d = K_{oc} \times f_{oc}$$

where

K_{oc}	=	Organic carbon-water partition coefficient (liter per kilogram [L/kg]; literature values)
f_{oc}	=	Fraction of organic carbon (unit; assumed 0.001)

The retardation factor for benzene in the Southeastern area was calculated to be 1.26 (see Appendix J).

Organic Carbon-Water Partition Coefficient (K_{oc})

For the input parameter K_{oc}, coefficients were applied to each COC based on literature sources (Pankow and Cherry 1995; Dragun 1998). For the HHRA COC benzene, K_{oc} is 38 L/kg.

Fraction of Organic Carbon (f_{oc})

For the input parameter typical f_{oc} values ranged from 0.002 to 0.02 [unit]. An assumed value of 0.001 (ASTM 1995) for f_{oc} was considered conservative because more organic carbon would allow higher adsorption of constituents on to soil solids. This assumption was applied for all HHRA and ERA COCs for all OU-2 areas.

Soil Bulk Density (ρ_b)

An assumed value of 1.70 kg/L was used for ρ_b at all OU-2 areas. This value is consistent with the general sediment type (clay sand) observed in the FWBZ at OU-2 sites (ASTM 1995).

Porosity (n)

The input parameter n equals effective porosity as used in Section 1 of the BIOSCREEN model and is 25 percent for all OU-2 areas.

Section 4, Biodegradation

First Order Decay Coefficient (λ)

The first order decay coefficient is calculated using the following equation:

$$\lambda = 0.593 / t_{half}$$

where

λ = First order decay coefficient (unit)
t_{half} = Dissolved plume transformation half-life (years)

The first order decay coefficient for benzene in the Southeastern area was calculated by Section 4 of the BIOSCREEN model to be 3.5×10^{-1} per year.

Dissolved Plume Transformation half-life (t_{half})

The input parameter t_{half} is the time in years for dissolved solute concentrations to diminish by one-half through chemical or biological means. Two years was used for transformation half-life for benzene, and one year was used for transformation half-life for xylenes (total) (ASTM 1995). A transformation half-life or zero was assumed for all other compounds.

Section 5, General

This section is concerned with the length and width of the plume and simulation time. All of these variables are input parameters as discussed below.

Modeled Area Length

The modeled area length was selected to coincide with the groundwater flow direction in each OU-2 area. For the HHRA, the maximum simulated distance to the nearest receptor was the distance from the COPC source to the nearest surface water body. For the HHRA COC benzene, the modeled area length was determined to be 1,125 feet in the Southeastern area based on plume data and the distance to San Francisco Bay based on the groundwater flow direction.

Modeled Area Width

The modeled area width was selected to be perpendicular to groundwater flow direction. This input parameter was a distance chosen to be wider than the source width as described under the heading of "Source Dimensions" discussed below and greater than the predicted lateral migration of the plume for the simulation times modeled. For benzene in the Southeastern area, the modeled area width was 100 feet.

Simulation Time

For the HHRA, 20 years was used as a minimum time period and 100 years was used as the maximum time period for simulating contaminant transport in groundwater.

Section 6, Source Data

Source Thickness in Saturation Zone

The source thickness in the saturation zone was assumed to be 10 feet for all COCs in all OU-2 areas.

Source Dimensions

The observed distribution of COCs in groundwater were used to estimate source area dimensions. Plume configurations were based on average groundwater concentrations observed during 1994 and 1995 groundwater sampling. For chemicals that do not have an identifiable dissolved plume, source width and length were set equal to half the distance to the nearest monitoring well where the chemical was not detected or 100 feet, whichever is smaller. This assumption is conservative because it allows for a relatively large source area and large soluble mass available for dissolution in groundwater.

Source depth was set equal to the screened length of the monitoring well with the highest detected chemical concentration. The source dimensions for the simulated COCs are summarized in Chapter 6 through 10.

Source Zone Concentration

The maximum concentrations of human health and ecological COCs observed during the 1994 and 1995 groundwater sampling rounds were used to simulate initial dissolved source COC concentrations. This is conservative because it assumes that the highest measured concentrations occur over the presumed extent of the simulated source. The maximum concentrations of simulated COCs detected in groundwater are presented in Chapters 6 through 10.

Soluble Mass

The additional soluble mass of COCs available for dissolution in groundwater was estimated based on maximum soil and groundwater concentrations and source area dimensions. The sum of soluble mass resulting from the adsorbed and dissolved phase was used to estimate the total soluble mass. Soluble mass in groundwater was calculated by applying the maximum measured concentrations over the entire plume volume using the following equation:

$$S_{gw} = (C_{ms})(V_{cg})$$

where

S_{gw}	=	Soluble mass in groundwater (unit)
C_{ms}	=	Maximum concentration in groundwater (unit)
V_{cg}	=	Volume of contaminated groundwater (unit)

In the Southeastern area, the maximum groundwater concentration of benzene was 39.5 micrograms per liter (µg/L) and the volume of benzene-contaminated groundwater was 707,795 L, making the soluble mass of benzene in groundwater 0.4077 kg (see Table 6-72).

Soluble mass in soil was calculated by applying the maximum measured concentrations over the entire plume volume according to the following equation:

$$S_s = (Cs)\,[(LWD)]\,\rho_b$$

where

S_s	=	Soluble mass in soil (units)
C_s	=	Maximum concentration in soil (unit)
LWD	=	Product of the source length, width, and depth (unit)
ρ_b	=	Solid bulk density (unit)

The maximum concentration of benzene in the soil was 3.3 mg/kg. The source length and width were 60 feet each. The source depth was 10 feet. The solid bulk density is 1.7 kg/L (as discussed above). Therefore, the soluble mass in soil is 5.715 kg, and the total soluble mass is 6 kg.

Source half-life ($t_{half\text{-}life}$)

This total mass estimate is used by the BIOSCREEN model to estimate the source half-life according to the following equation:

$$t_{half\text{-}life} = (0.593 \times M_o)/(Q \times C_o)$$

where

$t_{half\text{-}life}$	=	Half-life of source concentration
Q	=	Groundwater flow through source zone
C_o	=	Effective source zone concentrations at t = 0 (observed maximum dissolved concentration)
M_o	=	Mass of dissolvable organics in source zone at t = 0

The BIOSCREEN model calculated that the source half-life for benzene in the Southeastern area is 20 years.

Section 7, Field Data for Comparison

This section of the BIOSCREEN model was not used.

Section 8, Output

This section of the BIOSCREEN model provides output options for the modeler.

Unnumbered Section, Dissolved Chemical Concentrations in Plume

This section of BIOSCREEN presents plume concentrations at lateral and traverse distances from the COC source and a plot of plume concentrations versus lateral and traverse distances. Calculations of plume mass, mass flux, and other calculations are also presented in this section.

5.3.4 Modeling Results and Uncertainties

HHRA fate and transport modeling results are presented in Appendix J.

Significant uncertainties exist regarding the level of site characterization, knowledge of site-specific subsurface flow and transport conditions, and chemical properties. To compensate for these uncertainties, transport modeling used many conservative, simplified assumptions. These conservative assumptions tend to overestimate the amount of chemical mass, extent of migration, and concentration at the point of potential exposure. Conceptualizing and simplifying existing soil and groundwater conditions may result in discrepancies between predicted and actual results. For example, potential inaccuracies can arise by applying two-dimensional transport models to three-dimensional contaminant plumes and in simplifying the subsurface by assuming isotropic and homogenous conditions.

As a result of these potential inaccuracies, the results of contaminant transport modeling should be used carefully and not exclusively in any decision-making process. If a modeling result suggests a potential for exposure, the characterization data and modeling assumptions should be further evaluated prior to making a remedy decision. At a minimum, the modeling assumptions should be evaluated and understood before any modeling results are used for remedial design or risk assessment.

TABLE 5-1
EPA AND DTSC CANCER SLOPE FACTORS
HUMAN HEALTH RISK ASSESSMENT
OU-2, ALAMEDA POINT

Chemical	DTSC 1994 Database		EPA Current Database	
	Oral Cancer Slope Factor $(mg/kg\text{-}d)^{-1}$	Inhalation Cancer Slope Factor $(mg/kg\text{-}d)^{-1}$	Oral Cancer Slope Factor $(mg/kg\text{-}d)^{-1}$	Inhalation Cancer Slope Factor $(mg/kg\text{-}d)^{-1}$
Beryllium [(a)]	7	7	NA	8.4 (Updated 1998)
Chromium [(b)]	0.42	510	NA	42 (Updated 1998)
Benzene	0.1	0.1	0.029	0.029
Polychlorinated biphenyls	7.7	7.7	2.0	0.4 (Updated 1997)
Benzo(a)pyrene	12	3.9	7.3	Not determined
Benzo(b)fluoranthene	1.2	0.39	0.73	Not determined
Chlordane	1.2	1.2	0.35	0.35 (Updated 1997)

Notes:

(a) Beryllium is considered a carcinogen through the ingestion pathway in the DTSC database and not a carcinogen through the ingestion pathway in the EPA database.
(b) All chromium detected at OU-2 sites is assumed to be the carcinogenic hexavalent form, which is a very conservative assumption.

mg/kg-d	Milligram per kilogram-day
EPA	U.S. Environmental Protection Agency
DTSC	California Department of Toxic Substances Control
NA	Not available

TABLE 5-2
SUMMARY OF EXPOSURE SCENARIOS AND PATHWAYS
HUMAN HEALTH RISK ASSESSMENT
OU-2, ALAMEDA POINT
(Page 1 of 2)

Site	Residential [a]	Occupational/ Industrial [b]	Recreational [c]	Construction Worker [c]	Future Site Reuse [d]
OU-2 Southeastern Area					
9	X	X	X	X	**Inner Harbor:** Mixed-use area with a major emphasis on research and development and light industrial uses
13	X	X	X	X	
19	X	X	X	X	
22	X	X	X	X	
23	X	X	X	X	
OU-2 Eastern Area					
3	X	X	X	X	**Civic Core:** Mixed-use area with a major emphasis on research and development and industrial "flex" uses
4	X	X	X	X	**Inner Harbor:** Mixed-use area with a major emphasis on research and development and light industrial uses
11	X	X	X	X	**Marina:** Mixed-use area with a major emphasis on marina, civic, residential, and recreational uses
21	X	X	X	X	
OU-2 Central Area					
5	X	X	X	X	**Civic Core:** Mixed-use area with a major emphasis on research and development and industrial "flex" uses
10	X	X	X	X	
12	X	X	X	X	
Other OU-2 Sites					
14	X	X	X	X	**Northwest Territories:** Mixed-use area with a major emphasis on international trade and commerce and light industrial uses

TABLE 5-2
SUMMARY OF EXPOSURE SCENARIOS AND PATHWAYS
HUMAN HEALTH RISK ASSESSMENT
OU-2, ALAMEDA POINT
(Page 2 of 2)

Site	Residential[a]	Occupational/ Industrial[b]	Recreational [c]	Construction Worker [c]	Future Site Reuse [d]
25	X	X	X	X	**Main Street Neighborhood:** Mixed-use area with a major emphasis on research and development and light industrial uses

Notes:

(a) Residential scenarios were evaluated at the request of the regulatory agencies. Results of the evaluation are presented in Attachment 2 of Appendix D. Residential exposure scenarios include the following pathways:

Incidental soil ingestion
Dermal contact with soil
Inhalation of particulates in ambient air
Inhalation of vapors from surface soil in ambient air
Inhalation of vapors from groundwater in indoor air
Inhalation of volatiles while showering
Ingestion of groundwater
Ingestion of fruits and vegetables
Dermal contact with groundwater

(b) Occupational/Industrial exposure scenarios include the following pathways:

Incidental soil ingestion
Dermal contact with soil
Inhalation of particulates from soil in ambient air
Inhalation of vapors from soil in ambient air
Inhalation of vapors from groundwater in indoor air

(c) Recreational/Construction Worker exposure scenarios include the following pathways:

Incidental soil ingestion
Dermal contact with soil
Inhalation of particulates from soil in ambient air
Inhalation of vapors from soil in ambient air

(d) Future Site Reuse as described in NAS Alameda Community Reuse Plan (ARRA 1996).

TABLE 5-3
TOXICITY ASSESSMENT
CARCINOGENIC SLOPE FACTORS
OU-2, ALAMEDA POINT
(Page 1 of 4)

Chemical	Carcinogenic Classification	CSF [a] $(mg/kg\text{-}d)^{-1}$	CSF_t [a] $(mg/kg\text{-}d)^{-1}$	Critical Effect	Source
Inorganic Compounds					
Arsenic	A	1.5	50 (12)	Multiple cancers	EPA 1998
Beryllium	B2	ND (7)	8.4 (7)	Lung tumors	EPA 1998
Cadmium	B1	ND	6.3 (15)	Lung cancer	EPA 1998
Chromium	A	ND (0.42)	42 (510)	Lung cancer	EPA 1998
Nickel	A	ND	0.84 (0.91)	Lung and nasal tumors	EPA 1998
Polychlorinated Biphenyls					
Aroclor-1248	B2	RME = 2 (7.7); Average = 1 (7.7)	0.4 (7.7)	Liver tumors	EPA 1998
Aroclor-1254	B2	RME = 2 (7.7); Average = 1 (7.7)	0.4 (7.7)	Liver tumors	EPA 1998
Aroclor-1260	B2	RME = 2 (7.7); Average = 1 (7.7)	0.4 (7.7)	Liver tumors	EPA 1998
Pesticides and Herbicides					
alpha-Chlordane	B2	0.35 (1.2)	0.35 (1.2)	Hepatocellular carcinoma	EPA 1998
Aldrin	B2	17	17	Liver tumors	EPA 1998
Dichlorodiphenyldichloroethane	B2	0.24	ND (0.24)	Liver tumors	EPA 1998
Dichlorodiphenyltrichloroethylene	B2	0.34	[0.34 [b]] (0.24)	Liver and lung tumors	EPA 1998
Dichlorodiphenyltrichloroethane	B2	0.34	0.34	Liver tumors	EPA 1998
Dieldrin	B2	16	16	Tumorigenic potential	EPA 1998
gamma-Chlordane	B2	0.35 (1.2)	0.35 (1.2)	Hepatocellular carcinoma	EPA 1998
Heptachlor	B2	4.5 (5.7)	4.5 (5.7)	Liver carcinoma	EPA 1998

TABLE 5-3
TOXICITY ASSESSMENT
CARCINOGENIC SLOPE FACTORS
OU-2, ALAMEDA POINT
(Page 2 of 4)

Chemical	Carcinogenic Classification	CSF [(a)] $(mg/kg\text{-}d)^{-1}$	CSF_i [(a)] $(mg/kg\text{-}d)^{-1}$	Critical Effect	Source
Heptachlorodibenzo-p-dioxin	B2	1,500 (1,300)	1,500 (1,300)	Respiratory system and liver tumors	EPA 1995
Heptachlorodibenzo-p-furan	B2	1,500 (1,300)	1,500 (1,300)	Respiratory system and liver tumors	EPA 1995
Hexachlorodibenzo-p-dioxin	B2	15,000 (3,300)	15,000 (3,300)	Respiratory system and liver tumors	EPA 1995
Hexachlorodibenzo-p-furan	B2	15,000 (3,300)	15,000 (3,300)	Respiratory system and liver tumors	EPA 1995
Octachlorodibenzodioxin	B2	150 (130)	150 (130)	Respiratory system and liver tumors	EPA 1995
Octachlorodibenzofuran	B2	150 (130)	150 (130)	Respiratory system and liver tumors	EPA 1995
Pentachlorodibenzofuran	B2	75,000 (65,000)	75,000 (65,000)	Respiratory system and liver tumors	EPA 1995
Toxaphene	B2	1.1 (1.2)	1.1 (1.2)	Hepatocellular and thyroid tumors	EPA 1998
Semivolatile Organic Compounds					
Benzo(a)anthracene	B2	0.73 (1.2)	ND (0.39	Multiple cancers	EPA 1998
Benzo(a)pyrene	B2	7.3 (12)	ND (3.9)	Multiple cancers	EPA 1998
Benzo(b)fluoranthene	B2	0.73 (1.2)	ND (0.39)	Multiple cancers	EPA 1998
Benzo(k)fluoranthene	B2	0.073 (0.12)	ND (0.039)	Multiple cancers	EPA 1998
Bis(2-ethylhexyl)phthalate	B2	0.014 (0.0084)	ND (0.0084)	Liver tumors	EPA 1998
Bis(2-chloroethyl)ether	B2	1.1 (2.5)	1.155 (2.5)	Carcinogenicity in laboratory animals	EPA 1998
Carbazole	B2	0.02	ND	Multiple cancers	EPA 1998
Chrysene	B2	0.0073 (0.012)	ND (0.0039)	Multiple cancers	EPA 1998
Dibenzo(a,h)anthracene	B2	7.3 (12)	ND (3.9)	Multiple cancers	EPA 1998
Indeno(1,2,3-c,d)pyrene	B2	0.73 (1.2)	ND (0.39)	Multiple cancers	EPA 1998

TABLE 5-3
TOXICITY ASSESSMENT
CARCINOGENIC SLOPE FACTORS
OU-2, ALAMEDA POINT
(Page 3 of 4)

Chemical	Carcinogenic Classification	CSF [(a)] $(mg/kg\text{-}d)^{-1}$	CSF_i [(a)] $(mg/kg\text{-}d)^{-1}$	Critical Effect	Source
Methylene chloride	B2	0.0075 (0.014)	0.0016 (0.0035)	Hepatocellular and lung neoplasms	EPA 1998
n-Nitroso-di-n-propylamine	B2	7	[7 [(b)]] (7)	Increased tumor incidence	EPA 1998
n-Nitrosodiphenylamine	B2	0.049 (0.009)	ND (0.009)	Increased bladder tumors and reticulum cell carcinomas	EPA 1998
Pentachlorophenol	B2	0.12 (0.018)	[0.12 [(b)]] (0.018)	Tumorigenic potential	EPA 1998
Volatile Organic Compounds					
1,1-Dichloroethane	C	ND (0.0057)	ND (0.0057)	Adenocarcinomas and hemangiosarcomas	EPA 1998
1,2-Dichloroethane	C	0.091 (0.07)	0.091 (0.07)	Adenocarcinomas and hemangiosarcomas	EPA 1998
1,1-Dichloroethene	C	0.6 (ND)	0.18 (ND)	Tumor induction	EPA 1998
1,4-Dichlorobenzene	D	ND (0.04)	ND (0.04)	Hepatocellular adenoma and carcinoma of adrenal gland	Cal/EPA 1994
1,2-Dichloropropane	ND	ND (0.063)	ND (0.063)	Hepatocellular adenoma and carcinoma	Cal/EPA 1994
Benzene	A	0.029 (0.1)	0.029 (0.1)	Leukemia	EPA 1998
Bromodichloromethane	B2	0.062 (0.13)	[0.062 [(b)]] (0.13)	Kidney, liver, and intestinal tumors	EPA 1998
Chloroform	B2	0.061 (0.031)	0.081 (0.019)	Tumorigenic potential	EPA 1998
Dibromochloromethane	C	0.084 (0.094)	ND (0.094)	Evidence of carcinogenicity in laboratory animals	EPA 1998
Tetrachloroethene	B2-C	0.052 (0.051)	0.002 (0.021)	Liver tumors	SHRTSC 1994
Trichloroethene	B2-C	0.011 (0.015)	0.006 (0.01)	Liver tumors	SHRTSC 1994
Vinyl chloride	A	1.9 (0.27)	0.3 (0.27)	Liver tumors	EPA 1995

TABLE 5-3
TOXICITY ASSESSMENT
CARCINOGENIC SLOPE FACTORS
OU-2, ALAMEDA POINT
(Page 4 of 4)

Notes:

(a) Slope factors from California Department of Toxic Substances Control are shown in parentheses where they differ from EPA values.

(b) The toxicity value for the inhalation pathway was route-to-route extrapolated from the oral toxicity value without adjustment at the direction of the EPA Region 9 toxicologist. This is not an EPA-promulgated toxicity value and does not account for route of exposure or for pharmacokinetic or physiological considerations.

mg/kg-d	Milligram per kilogram-day
Cal/EPA	California Environmental Protection Agency
CSF_i	Cancer slope factor inhalation
CSF_o	Cancer slope factor oral
EPA	U.S. Environmental Protection Agency
ND	Not determined
RME	Reasonable maximum exposure
SHRTSC	Superfund Health Risk Technical Support Center

TABLE 5-4
TOXICITY ASSESSMENT
NONCARCINOGENIC TOXICITY VALUES
OU-2, ALAMEDA POINT
(Page 1 of 5)

Chemical	RfD_0 (mg/kg-d)	UF (unitless)	RfD_i (mg/kg-d)	UF (unitless)	Critical Effect	Source
Inorganic Compounds						
Aluminum	1	100	ND	ND	Neurotoxicity	SHRTSC 1994
Antimony	0.0004	1,000	ND	ND	Increased mortality and altered blood chemistry	EPA 1998b
Arsenic	0.0003	3	ND	ND	Hyperpigmetation, keratosis, and vascular changes	EPA 1998b
Barium	0.07	3	ND	ND	Increased blood pressure and kidney weight	EPA 1998
Beryllium	0.002	300	0.006	10	Intestinal lesions and sensitization	EPA 1998
Cadmium	0.001 (food) 0.0005 (water)	10	ND	ND	Significant proteinuria	EPA 1998b
Chromium	0.003	300	0.000029	300	Intestinal lesions and sensitization	EPA 1998b
Cobalt	0.06	ND	0.00029	ND		EPA 1996
Copper	0.037	ND	ND	ND	Based on maximum contaminant level for water	EPA 1995
Cyanide (free)	0.02	100	ND	ND	Weight loss, thyroid effects, and myelin degeneration	EPA 1998b
Lead	ND	ND	ND	ND	ND	ND
Manganese	0.14	1	0.000014	1,000	Central nervous system effects and neurological impairments	EPA 1998b
Mercury	0.0003	1,000	ND	ND	Autoimmune effects	EPA 1995
Molybdenum	0.005	30	ND	ND	Increased uric acid levels	EPA 1998b
Nickel	0.02	300	ND	ND	Decreased body weight and organ weights	EPA 1998b
Selenium	0.005	3	ND	ND	Clinical selenosis	EPA 1998b
Silver	0.005	3	ND	ND	Argyria	EPA 1998b
Thallium	0.00008	3,000	ND	ND	Alopecia, increased serum GOT and serum LDH	EPA 1998b

TABLE 5-4
TOXICITY ASSESSMENT
NONCARCINOGENIC TOXICITY VALUES
OU-2, ALAMEDA POINT
(Page 2 of 5)

Chemical	RfD_o (mg/kg-d)	UF (unitless)	RfD_i (mg/kg-d)	UF	Critical Effect	Source
Titanium	ND	ND	ND	ND	ND	ND
Vanadium	0.007	100	ND	ND	No observed adverse effects level	EPA 1995
Zinc	0.3	3	ND	ND	Red blood cell changes (decreases in erythrocyte superoxide dismutase)	EPA 1998b
Polychlorinated Biphenyls						
Aroclor-1248	ND	ND	ND	ND	ND	ND
Aroclor-1254	0.00002	300	ND	ND	Ocular effects antibody effects and distorted growth	EPA 1998b
Aroclor-1260	ND	ND	ND	ND	ND	ND
Pesticides and Herbicides						
a-Chlordane	0.0005	300	0.0002	1,000	Hepatic necrosis and liver effects	EPA 1998b
Aldrin	0.00003	1,000	ND	ND	Liver toxicity	EPA 1998b
Dichlorodiphenyldichloroethane	ND	ND	ND	ND	ND	ND
Dichlorodiphenyltrichloroethylene	ND	ND	ND	ND	ND	ND
Dichlorodiphenyltrichloroethane	0.0005	100	ND	ND	Liver lesions	EPA 1998b
Dieldrin	0.00005	100	ND	ND	Liver lesions	EPA 1998b
Endosulfan II	0.006	100	ND	ND	Kidney and blood vessel effects and; increased body weight gain	EPA 1998b
g-Chlordane	0.0005	300	0.0002	1,000	Hepatic necrosis and liver effects	EPA 1998b
Heptachlor	0.0005	300	ND	ND	Increased liver weight	EPA 1998b
Dioxins						
Heptachlorodidenzo-p-dioxin	ND	ND	ND	ND	ND	ND
Heptachlorodibenzo-p-furan	ND	ND	ND	ND	ND	ND
Hexachlorodibenzodioxin	ND	ND	ND	ND	ND	ND
Hexachlorodibenzofuran	ND	ND	ND	ND	ND	ND
MCPP	0.001	3,000	ND	ND	Increased relative and absolute kidney weights	EPA 1998b

TABLE 5-4
TOXICITY ASSESSMENT
NONCARCINOGENIC TOXICITY VALUES
OU-2, ALAMEDA POINT
(Page 3 of 5)

Chemical	RfD_o (mg/kg-d)	UF (unitless)	RfD_i (mg/kg-d)	UF	Critical Effect	Source
Octachlorodibenzodioxin	ND	ND	ND	ND	ND	ND
Octachlorodibenzofuran	ND	ND	ND	ND	ND	ND
Pentachlorodibenzofuran	ND	ND	ND	ND	ND	ND
Semivolatile Organic Compounds						
2-Methylnaphthalene	ND	ND	ND	ND	ND	ND
2-Methylphenol	0.05	1,000	ND	ND	Decreased body weight and neurotoxicity	EPA 1998b
2,2-Oxybis(1-chloropropane)	ND	ND	ND	ND	ND	EPA 1998b
2,4-Dinitrophenol	0.002	1,000	ND	ND	Cataract formation	EPA 1998b
4-Methylphenol	ND	ND	ND	ND	ND	ND
4-Methyl-2-pentanone	ND	ND	ND	ND	ND	EPA 1998b
4,6-Dinitro-2-methylphenol	ND	ND	ND	ND	ND	EPA 1998b
Acenaphthene	0.06	3,000	ND	ND	Heptatoxicity	EPA 1998b
Acenapthylene	ND	ND	ND	ND	ND	ND
Anthracene	0.3	3,000	ND	ND	No observed effects level	EPA 1998b
Benzo(a)anthracene	ND	ND	ND	ND	ND	ND
Benzo(a)pyrene	ND	ND	ND	ND	ND	ND
Benzo(b)fluoranthene	ND	ND	ND	ND	ND	ND
Benzo(k)fluoranthene	ND	ND	ND	ND	ND	ND
Bis(2-ethylhexyl))phthalate	0.02	1,000	ND	ND	Increased relative liver weight	EPA 1998b
Bis(2-chloroethyl)ether	ND	ND	ND	ND	ND	ND
Carbazole	ND	ND	ND	ND	ND	ND
Chloroethane	ND	ND	ND	ND	ND	ND
Chrysene	ND	ND	ND	ND	ND	ND
Dibenzo(a,h)anthracene	ND	ND	ND	ND	ND	ND
Dibromochloromethane	0.02	1,000	0.02 [(a)]	ND	Hepatic lesions	EPA 1998b
Di-n-butylphthalate	0.1	1,000	ND	ND	Increased mortality	EPA 1998b
Diethylphthalate	0.8	1,000	ND	ND	Decreased growth rate, decreased food consumption, and altered organ weights	EPA 1998b

TABLE 5-4
TOXICITY ASSESSMENT
NONCARCINOGENIC TOXICITY VALUES
OU-2, ALAMEDA POINT
(Page 4 of 5)

Chemical	RfD_o (mg/kg-day)	UF (unitless)	RfD_i (mg/kg-day)	UF	Critical Effect	Source
Fluoranthene	0.04	3,000	ND	ND	Neuropathy and liver and blood effects	EPA 1998b
Fluorene	0.04	3,000	ND	ND	Decreased red blood cell count and blood effects	EPA 1998b
Indeno(1,2,3-c,d)pyrene	ND	ND	ND	ND	ND	ND
Methyl tertiary-butyl ether	ND	ND	0.86	100	Increased absolute and relative organ weights and kidney effects	EPA 1998b
n-Nitroso-di-n-propylamine	ND	ND	ND	ND	ND	ND
n-Nitrosodiphenylamine	ND	ND	ND	ND	ND	ND
Naphthalene	0.02	3,000	0.00086	3,000	Decreased body weight and nasal effects	EPA 1998b
Pentachlorophenol	0.03	100	0.03 [(a)]	ND	Liver and kidney pathology	EPA 1998b
Phenanthrene	ND	ND	ND	ND	ND	ND
Phenol	0.6	100	ND	ND	Reduced fetal body weight	EPA 1998b
Pyrene	0.03	3,000	ND	ND	Kidney effects	EPA 1998b
Volatile Organic Compounds						
1,1-Dichloroethane	0.1	1,000	0.1	1,000	Kidney damage	EPA 1995
1,1-Dichloroethene	0.009	1,000	ND	ND	Liver lesions	EPA 1998b
1,1,1-Trichloroethane	ND	ND	0.29	1,000	Neurological effects and decreased body weight gain	SHRTSC 1994
1,2-Dichloroethene (total)	0.009	1,000	0.009 [(a)]	ND	Liver lesions	EPA 1995
trans-1,2-Dichloroethene	0.02	1,000	0.02 [(a)]	ND	Increased serum alkaline phosphatase	EPA 1998b
1,2-Dichloroethane	ND	ND	ND	ND	ND	ND
1,2-Dichlorobenzene	0.09	1,000	ND	ND	No observed adverse effects level	EPA 1998b
1,2-Dichloropropane	ND	ND	0.0011	300	Hyperplasia of nasal mucosa	EPA 1998b
1,3-Dichlorobenzene	0.09	1,000	ND	ND	No observed adverse effects level	EPA 1998b
1,4-Dichlorobenzene	ND	ND	0.23	100	Increased liver weights	EPA 1998b
Acetone	0.1	1,000	0.1 [(a)]	ND	Increased liver and kidney weights and nephrotoxicity	EPA 1998b

TABLE 5-4
TOXICITY ASSESSMENT
NONCARCINOGENIC TOXICITY VALUES
OU-2, ALAMEDA POINT
(Page 5 of 5)

Chemical	RfD_o (mg/kg-d)	UF (unitless)	RfD_i (mg/kg-d)	UF	Critical Effect	Source
Benzene	ND	ND	ND	ND	ND	ND
Carbon disulfide	0.1	100	0.2	30	Fetal toxicity and malformations and peripheral nervous system disorders	EPA 1998b
Chlorobenzene	ND	ND	ND	ND	ND	ND
Chloroform	0.01	1,000	ND	ND	Fatty cyst formation in liver	EPA 1998b
Ethylbenzene	0.1	1,000	0.29	300	Liver, kidney and developmental toxicity	EPA 1998b
Methylene chloride	0.06	100	ND	ND	Liver toxicity	EPA 1998b
Methyl ethyl ketone (2-Butanone)	0.6	3,000	0.29	1,000	Decreased fetal birth weight	EPA 1998b
Tetrachloroethene	0.01	1,000	ND	ND	Hepatotoxicity	EPA 1998b
Trichloroethene	0.006	3,000	ND	ND	No observed adverse effects level	SHRTSC 1994
Toluene	0.2	1,000	0.11	300	Changes in liver and kidney weights and changes in neurological functions	EPA 1998b
Vinyl chloride	ND	ND	ND	ND	ND	ND
Xylene (total)	2	100	ND	ND	Hyperactivity, decreased body weights and increased mortality	EPA 1998b

Notes:

(a) The toxicity value for the inhalation pathway was route-to-route extrapolated from the oral toxicity value without adjustment at the direction of the EPA Region 9 toxicologist. This is not an EPA-promulgated toxicity value and does not account for route of exposure for pharmacokinetic or physiological considerations.

mg/kg-d Milligram per kilogram day
EPA U.S. Environmental Protection Agency
MCPP 2-(2-methyl-4-chlorophenoxy)-propionic acid
ND Not determined
RfD_i Reference dose inhalation
RfD_o Reference dose oral
SHRTSC Superfund Health Risk Technical Support Center
UF Uncertainty factor

TABLE 5-5
TERRESTRIAL HABITAT SUMMARY
OU-2, ALAMEDA POINT
(Page 1 of 2)

Site	Habitat Type	Dominant Vegetation	Observed Animal Species	Relative Occurrence
OU-2 Southeastern Area				
9	Urban/Ornamental Landscapes	None (paved)	None	NA
13	Disturbed Areas	Ryegrass (*Lolium* sp.) Common plantain (*Plantago* sp.) Fennel (*Foeniculum vulgare*)	Mourning dove (*Zenaida macroura*)	Common
19	Urban/Ornamental Landscapes	None (paved)	None	NA
22	Urban/Ornamental Landscapes	Perennial ryegrass (*Lolium perene*) Kentucky bluegrass (*Poa pratensis*) Cudweed (*Gnaphalium* sp.) Yellow sweetclover (*Melilotus officinalis*) Pine (*Pinus* sp.)	Squirrels (*Sciurus* sp.) Scrub jays (*Aphelocoma coerulescens*)	Common
23	Urban/Ornamental Landscapes	None (paved)	None	NA
OU-2 Eastern Area				
3	Urban/Ornamental Landscapes	Perennial ryegrass (*Lolium perene*) Kentucky bluegrass (*Poa pratensis*) Flowering plum (*Prunus* sp.) Olive (*Olea europaea*) Fir (*Abies* sp.) Pine (*Pinus* sp.)	American robin *(Turdus migratorius)* European starling *(Sturnus vulgaris)* Killdeer *(Charadrius vociferus)*	Common
4	Urban/Ornamental Landscapes	None (paved)	None	NA
11	Urban/Ornamental Landscapes	None (paved)	None	NA
21	Urban/Ornamental Landscapes	None (paved)	None	NA

TABLE 5-5
TERRESTRIAL HABITAT SUMMARY
OU-2, ALAMEDA POINT
(Page 2 of 2)

Site	Habitat Type	Dominant Vegetation	Observed Animal Species	Relative Occurence
OU-2 Central Area				
5	Urban/Ornamental Landscapes	None (paved)	None	NA
10	Urban/Ornamental Landscapes	None (paved)	None	NA
12	Urban/Ornamental Landscapes	None (paved)	None	NA
Other OU-2 Sites				
14	Disturbed Areas	Ryegrass (*Lolium* spp.) Common plantain (*Plantago* sp.) Fennel (*Foeniculum vulgare*)	Black-tailed jackrabbit (*Lepus californicus*) Feral rabbit (*Lepus* sp.)	NA
25	Urban/Ornamental Landscapes	Perennial ryegrass (*Lolium perene*) Kentucky bluegrass (*Poa pratensis*)	None	NA

Notes:

NA Not applicable
OU Operable Unit

TABLE 5-6
AQUATIC TOXICITY REFERENCE VALUES
ECOLOGICAL RECEPTORS
OU-2 ALAMEDA POINT
(Page 1 of 3)

Chemical	Literature-Based TRV (ug/L)	Source of TRV
Inorganic Chemicals		
Aluminum	87	EPA 1999b
Antimony	30	Suter et al. 1996
Arsenic	36	EPA 1999b
Barium	4.0	Suter et al. 1996
Beryllium	0.66	Suter et al. 1996
Bromide	NA	NA
Cadmium	9.3	EPA 1999b
Calcium	NA	NA
Chromium	50	EPA 1999b
Cobalt	23	Suter et al. 1996
Copper	3.1	EPA 1999b
Cyanide	5.2	EPA 1999b
Iron	NA	NA
Lead	3.1	EPA 1999b
Magnesium	NA	NA
Manganese	120	Suter et al. 1996
Mercury	0.94	EPA 1999b
Molybdenum	370	Suter et al. 1996
Nickel	8.2	EPA 1999b
Potassium	NA	NA
Radium 226	NA	NA
Radium 228	NA	NA
Selenium	71	EPA 1999b
Silver	NA	NA
Sodium	NA	NA
Thallium	12	Suter et al. 1996
Titanium	NA	NA
Zinc	81	EPA 1999b
Semivolatile Organic Chemicals		
2,2'-Oxybis(1-chloropropane)	NA	NA
2,4-Dichlorophenol	NA	NA
2,4-Dinitrophenol	NA	NA
2-Butanone	14000	Suter et al. 1996
2-Hexanone	NA	NA
2-Methylnaphthalene	2.1	Suter et al. 1996
2-Methylphenol	13	Suter et al. 1996
4,6-Dinitro-2-methylphenol	NA	NA
4-Chloro-3-methylphenol	NA	NA
4-Methylphenol	13	Suter et al. 1996
4-Nitrophenol	NA	NA
Acenaphthene	23	EPA 1999b
Anthracene	0.7	Suter et al. 1996
Benzo(a)anthracene	0.024	Suter et al. 1996
Benzo(a)pyrene	0.014	Suter et al. 1996
Benzo(b)fluoranthene	0.014	Suter et al. 1996

TABLE 5-6
AQUATIC TOXICITY REFERENCE VALUES
ECOLOGICAL RECEPTORS
OU-2 ALAMEDA POINT
(Page 2 of 3)

Chemical	Literature-Based TRV (ug/L)	Source of TRV
Semivolatile Organic Chemicals (Continued)		
Benzo(g,h,i)perylene	0.014	Suter et al. 1996
Benzo(k)fluoranthene	0.014	Suter et al. 1996
Bis(2-ethylhexyl)phthalate	3	Suter et al. 1996
Carbazole	0.014	Suter et al. 1996
Chrysene	0.014	Suter et al. 1996
Diethylphthalate	NA	NA
Fluoranthene	6.16	EPA 1999b
Fluorene	3.9	Suter et al. 1996
Indeno(1,2,3-cd)pyrene	0.014	Suter et al. 1996
Naphthalene	12	Suter et al. 1996
Pentachlorophenol	NA	NA
Phenanthrene	0.014	Suter et al. 1996
Phenol	110	EPA 1999b
Pyrene	0.014	Suter et al. 1996
Volatile Organic Chemicals		
1,1,1-Trichloroethane	11	Suter et al. 1996
1,1,2-Trichloroethane	NA	NA
1,1-Dichloroethane	47	Suter et al. 1996
1,1-Dichloroethene	25	Suter et al. 1996
1,2,4-Trichlorobenzene	NA	NA
1,2-Dichlorobenzene	14	Suter et al. 1996
1,2-Dichloroethane	910	Suter et al. 1996
1,2-Dichloroethene (total)	590	Suter et al. 1996
1,2-Dichloropropane	NA	NA
1,3-Dichlorobenzene	71	Suter et al. 1996
1,4-Dichlorobenzene	15	Suter et al. 1996
2,2'-Oxybis(1-chloropropane)	NA	NA
2,6-Dinitrotoluene	NA	NA
2-Butanone	14000	Suter et al. 1996
2-Hexanone	99	Suter et al. 1996
4-Chloro-3-methylphenol	NA	NA
4-Methyl-2-pentanone	170	Suter et al. 1996
Acetone	1500	Suter et al. 1996
Benzene	130	Suter et al. 1996
Bis(2-chloroethyl)ether	NA	NA
Bromodichloromethane	NA	NA
Butylbenzylphthalate	NA	NA
Carbon disulfide	0.92	Suter et al. 1996
Chlorobenzene	64	Suter et al. 1996
Chloroethane	NA	NA
Chloroform	28	Suter et al. 1996
Chloromethane	NA	NA
Cis-1,2-dichloroethene	590	Suter et al. 1996
Dibromochloromethane	NA	NA
Ethylbenzene	7.3	Suter et al. 1996

TABLE 5-6
AQUATIC TOXICITY REFERENCE VALUES
ECOLOGICAL RECEPTORS
OU-2 ALAMEDA POINT
(Page 3 of 3)

Chemical	Literature-Based TRV (ug/L)	Source of TRV
Volatile Organic Chemicals (Continued)		
Isophorone	NA	NA
N-nitrosodiphenylamine (1)	NA	NA
Tetrachloroethene	98	Suter et al. 1996
Toluene	9.8	Suter et al. 1996
Trans-1,2-dichloroethene	590	Suter et al. 1996
Trichloroethene	47	Suter et al. 1996
Vinyl chloride	NA	NA
Xylene (total)	13	Suter et al. 1996

TRV - Toxicity reference value

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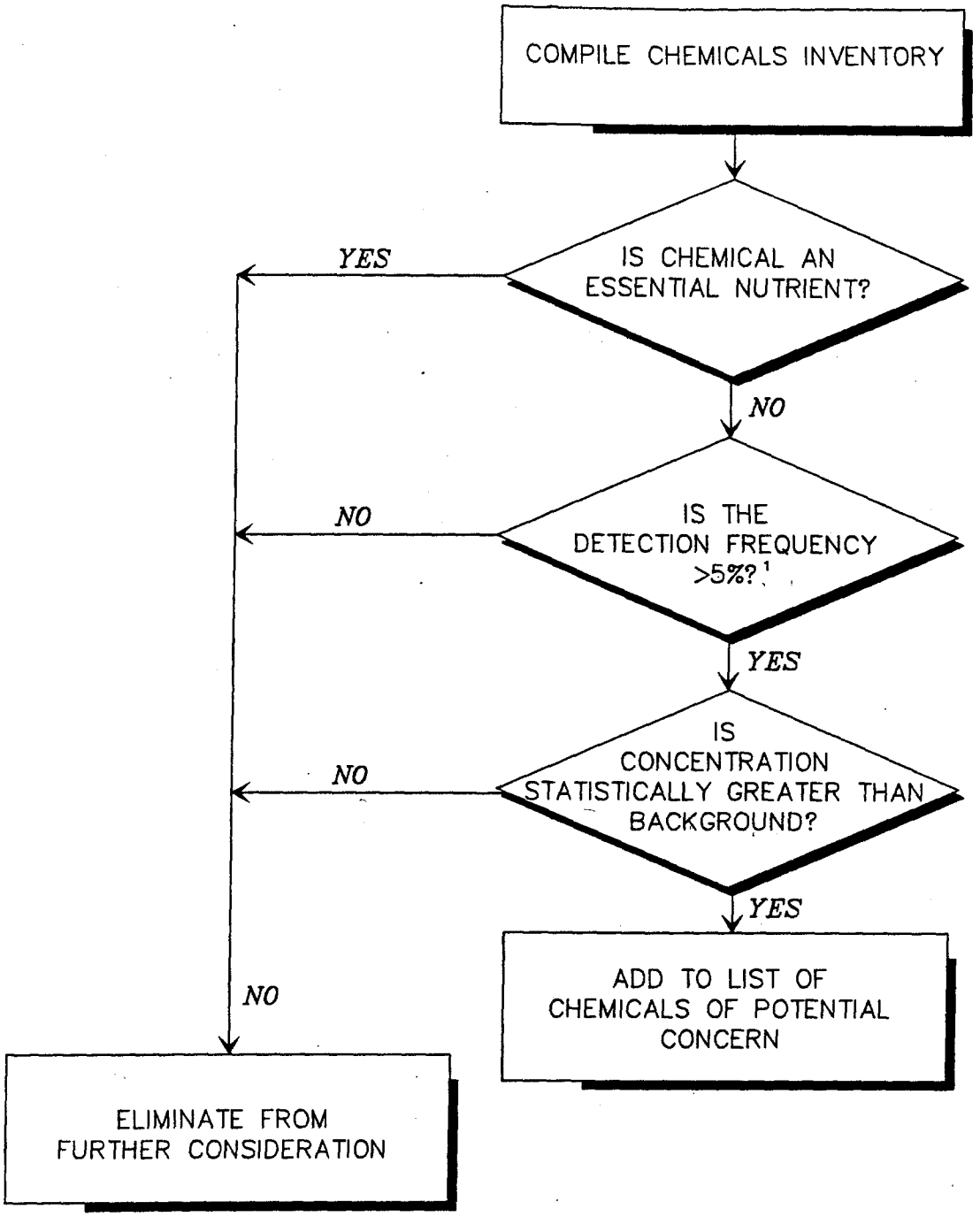
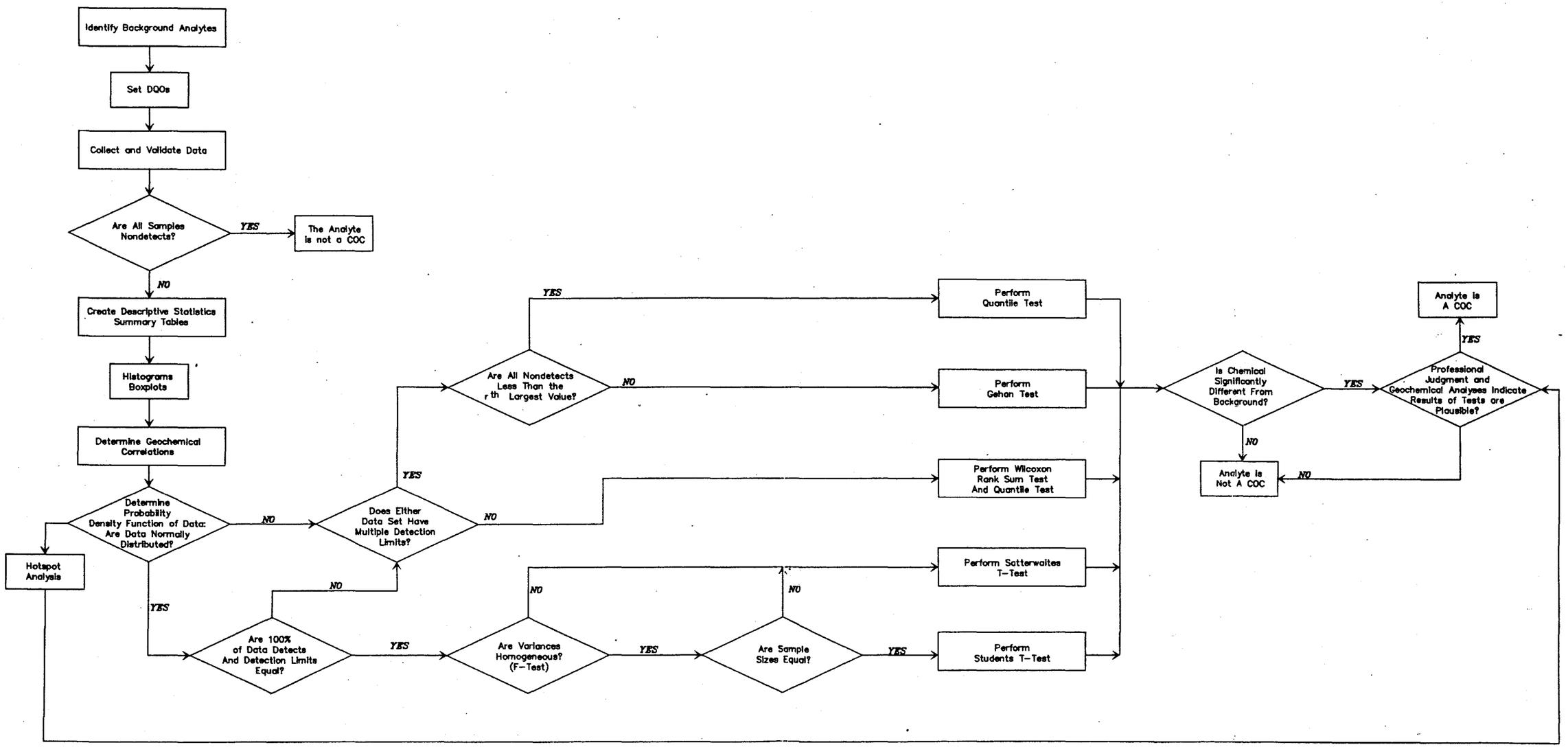


[1] INCLUDES A COMPARISON OF MAXIMUM DETECTED CONCENTRATION TO ONE-TENTH OF THE RESIDENTIAL PRG.

FIGURE 5-1
COPC IDENTIFICATION
DECISION FLOW CHART
ALAMEDA POINT
ALAMEDA, CALIFORNIA

ALA-1.DWG - 08/20/98 - RAO - 069-16680202



* See Section 5.1 for description of r.

FIGURE 5-2
DECISION FLOW CHART -
COMPARISON OF SITE AND
BACKGROUND DATA
ALAMEDA POINT
ALAMEDA, CALIFORNIA

ALA-PT-B.DWG 3/20/98 - RAO - 069-16850202

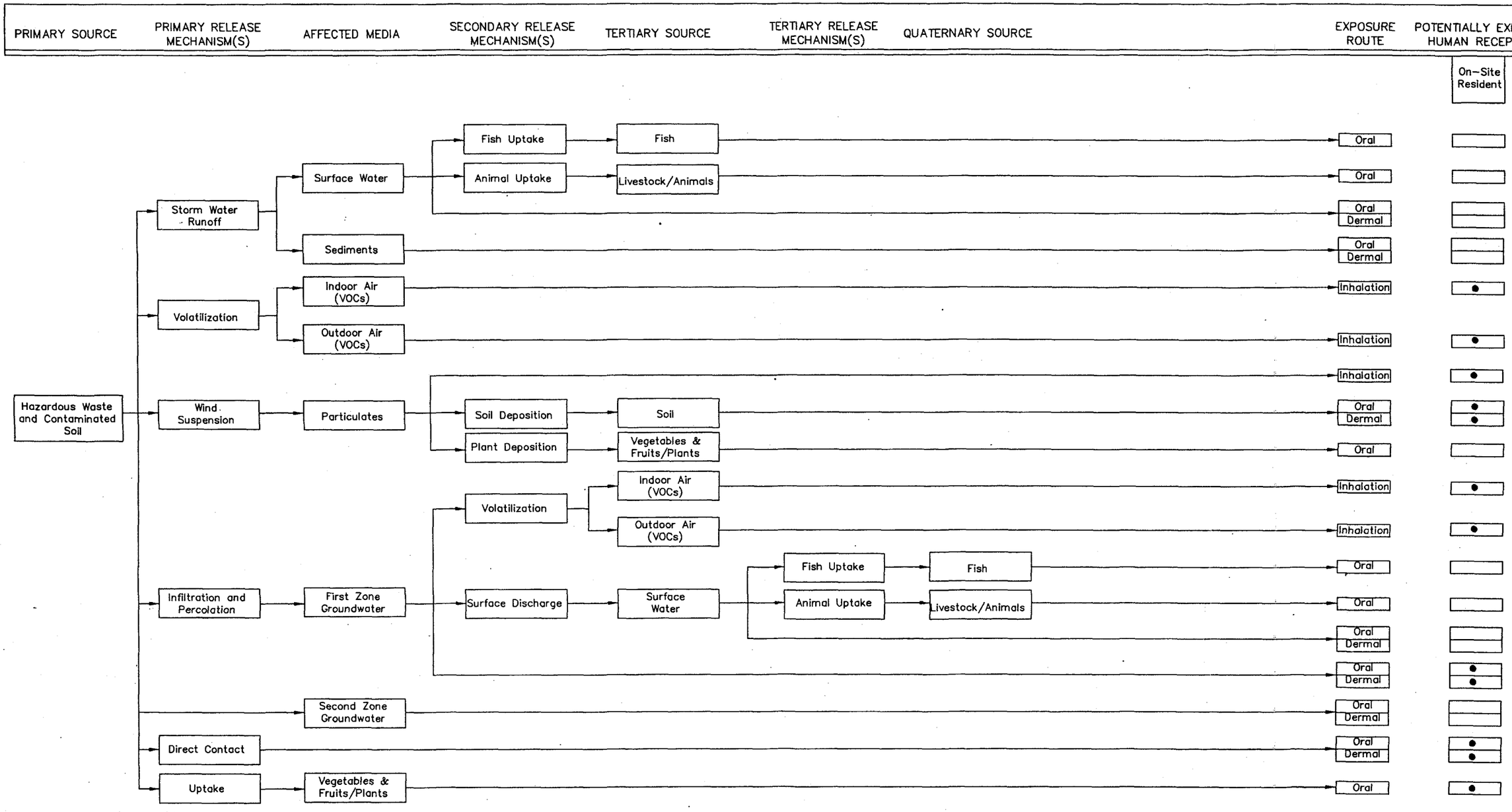


FIGURE 5-3a
CONCEPTUAL MODEL
POTENTIALLY COMPLETE EXPOSURE PATHWAYS
RESIDENTIAL RECEPTORS
ALAMEDA POINT
ALAMEDA, CALIFORNIA

ALA-PT-8.DWG - 08/20/98 - RAO - 069-16680202

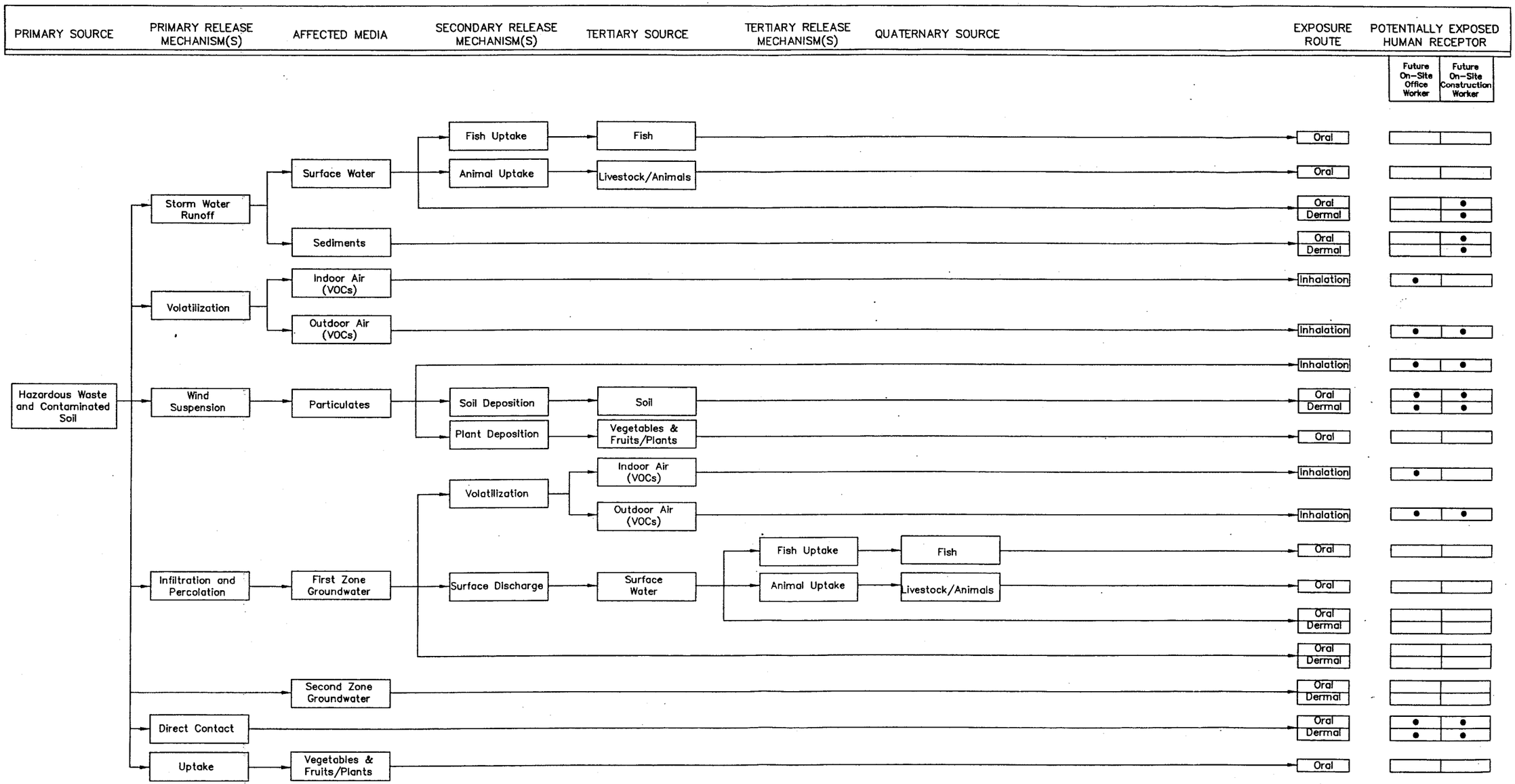


FIGURE 5-3b
CONCEPTUAL MODEL
POTENTIALLY COMPLETE EXPOSURE PATHWAYS
OCCUPATIONAL RECEPTORS
ALAMEDA POINT
ALAMEDA, CALIFORNIA

ALA-PT-B.DWG - 08/20/98 - RAO - 069-16680202

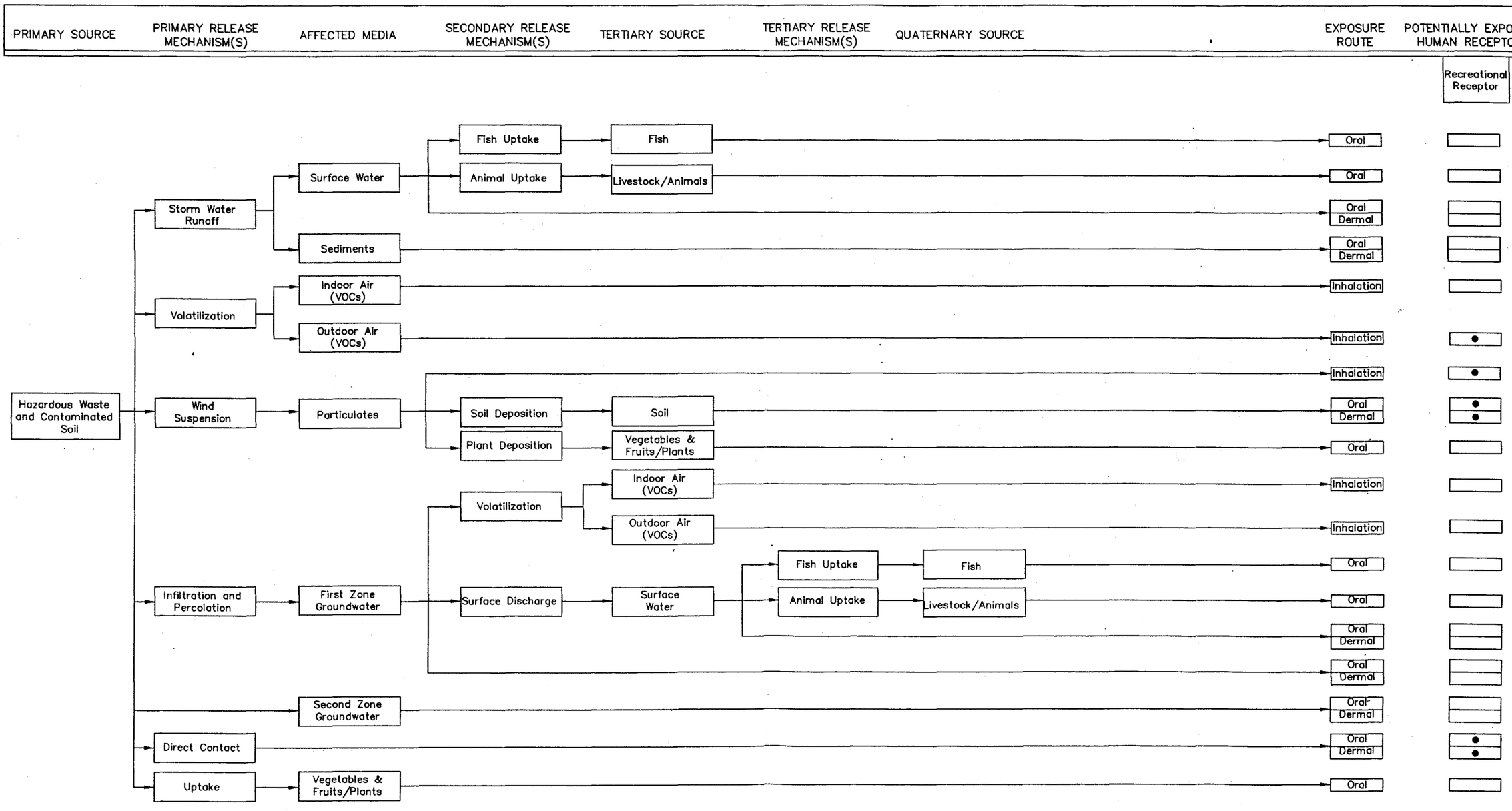
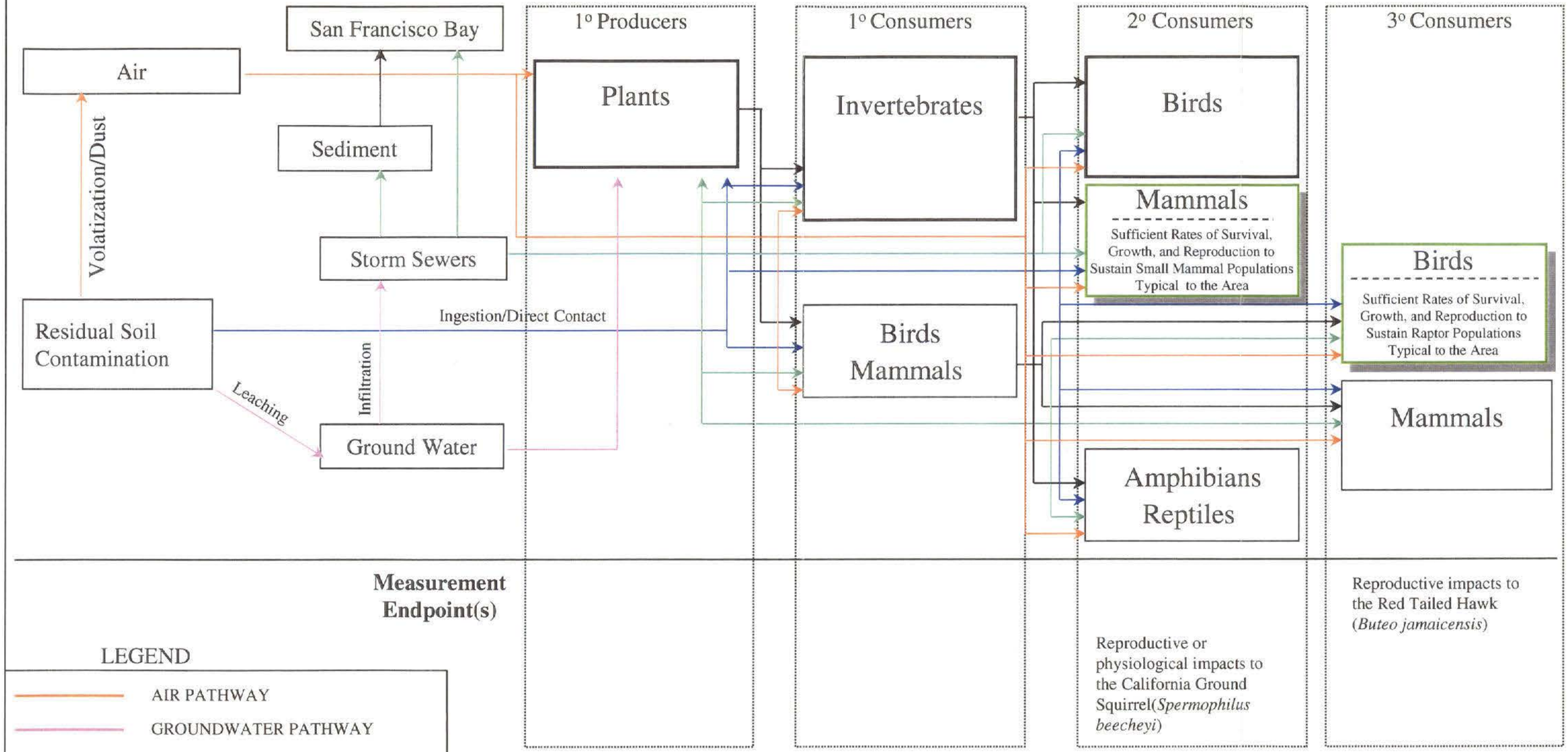


FIGURE 5-3c
CONCEPTUAL MODEL
POTENTIALLY COMPLETE EXPOSURE PATHWAYS
RECREATIONAL RECEPTORS
ALAMEDA POINT
ALAMEDA, CALIFORNIA

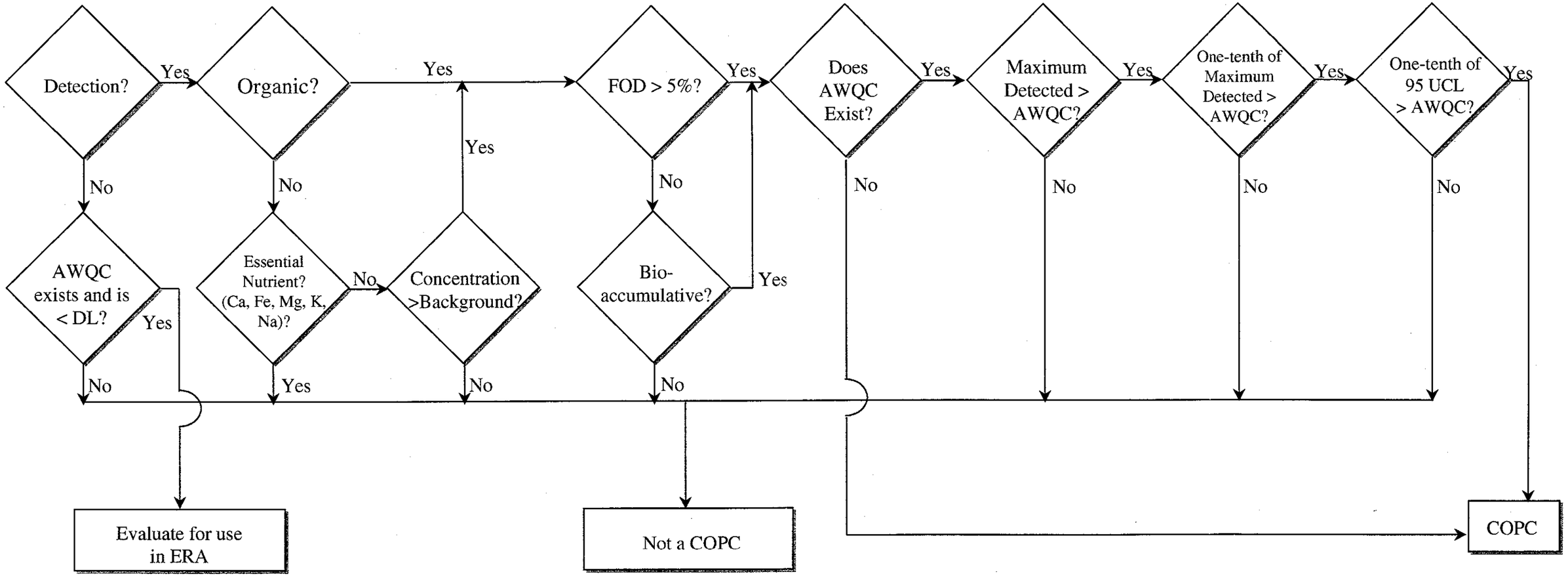
ALA-PT-8.DWG - 08/20/98 - RAO - 069-16680202



Alameda Point

FIGURE 5-4
GENERIC OPERABLE UNIT 2 ECOLOGICAL CONCEPTUAL SITE MODEL

Tetra Tech EM Inc.



AWQC = ambient water quality criteria
DL = method detection limit
FOD = frequency of detection
95UCL = 95th upper confidence level

FIGURE 5-5

PROCEDURE FOR IDENTIFYING ECOLOGICAL COPCS IN GROUNDWATER AT OU-2
ALAMEDA POINT
ALAMEDA, CALIFORNIA

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